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Field Work of Reinforced Concrete.

The application of reinforced concrete to such classes of work as building construction has created requirements not to the same extent imperative in other branches of construction. It is necessary in a building where the masses of concrete are comparatively small, and especially in such parts as thin floor slabs, that the material should be as nearly continuous at every point as it is possible to make it. This not only eliminates all spongy or porous places, but also produces a smooth, continuous surface which is so essential in concrete building construction. As a matter of fact there is no more pressing requirement, not yet fully attained, than that a continuous surface in a concrete building shall be found on the removal of the forms. The direction in which the greatest advance is necessary at the present time is in this particular. Any procedure, either as to the making of forms or of manipulating the concrete in the field, which conduces to this end is, therefore, of great consequence.

It is this feature of reinforced concrete construction, probably more than any other, which gives importance to such instructions for reinforced concrete field work as those of which a short abstract appeared in the issue of The Engineering Record of April 6. Without criticising in detail either favorably or unfavorably any part of these instructions, it may be properly stated that such directions for the conduct of reinforced concrete work in the field are of the greatest importance at the present time. It is imperative that in the rapid extension of this class of engineering work all its conditions should be thoroughly considered to the last detail. No experienced engineer can be responsible for the results of this branch of construction without being impressed by the necessity of systematizing and controlling every step of the work at the site of a building, from the mixing of the concrete to the final completion of the job.

The construction of the forms may be either a source of loss through ill-considered plans or of economy by well-considered design and handling of those forms. Fresh concrete suitable for this class of construction is practically semi-liquid and of high density. The forms, therefore, must be comparatively heavy in order to carry this semi-liquid without sensible distortion or material leakage. They must be firmly held together and well supported and yet their fastenings and their supports must be of such character as to permit ready removal with the least possible work and within a minimum time. These requirements have not yet been satisfactorily fulfilled, to any great extent, although they doubtless will be as experience in this line of work is extended. The forms and their supports are too often nailed or permanently put together, requiring costly effort to detach them and too frequently the use of the sledge and iron bar, the latter levering against the new concrete and badly marring it, as well as unnecessarily injuring the forms themselves. What is needed above all is such a system of design and construction of forms as will give well-supported, smooth and even interior surfaces for the reception of the concrete, combined with easily and quickly removed fastenings, permitting the forms mostly to fall away from the concrete, but in no case requiring the brutal and costly means now so often necessary.

A further improvement, as to both the work and economy in construction, can be secured by adopting a greater uniformity of exterior dimensions for the columns, beams and girders of the building to be constructed, and as far as possible by having a simple and uniform system of varying dimensions where such variations must be made. In a high building the outside dimensions of columns must necessarily change in passing from basement to roof, but with suitable care in design these variations can be greatly reduced, and every reduction means material economy as well as expediting the work. Similarly, where floor loads are varied, intelligent care in the design of beams and girders will frequently lead to the retention of uniformity in the outside dimensions with varying amounts of reinforcement to meet the requirements of changing loads. A little extra concrete will usually cost much less than expensive carpenter work in modifying and repairing forms to fit an otherwise necessary range of outside dimensions.

The clearing of column and other forms of the usual dirt and debris inevitably collected about work in progress before pouring concrete cannot be too much insisted upon. This procedure appears like a useless refinement to most untrained foremen and laborers, but it constantly makes the difference between good work and that which is bad or even dangerous. It is no less important than proper concrete. A comparatively small amount of debris breaking the continuity of the concrete in a column may largely reduce its carrying capacity. Sawdust, shavings and small wooden blocks in a loosely connected mass do not make a fit substitute for first-class concrete.

It is not necessary to say much at the present time as to the necessity or excellence of wet concrete, for they are too widely recognized. What may be termed a semi-liquid mixture is absolutely essential for proper results in building work. More than this, it is equally imperative that the freshly poured concrete should be thoroughly agitated throughout its entire mass to make a smooth, continuous exterior surface, and to perfect a solid and intimate bond with the steel reinforcement.

With compliance with these and other suitable instructions for field work, including the abundant use of enclosing canvas and salamanders, at times of low temperature, the highest degree of excellence may be attained in reinforced concrete building work in all seasons of the year, including some of the coldest winter weather.

Engineering Chemistry in the Power Plant.

General recognition of the importance of perfecting the operation of all parts of the power plant has led recently to a wider interest in the problems of fuel combustion than can be credited to any previous period in engineering practice. Greater care is being taken to secure accurate data of boiler performance from the coal scales to the chimney passes, and many managers are earnestly striving to interpret these statistics in a way which will lead to the more efficient production of each unit of power. In industrial plants where the cost of power is but a small percentage of the total expense of manufacture, there is obviously not the same incentive to pay for high-priced analytical work that obtains in central stations, but unless the actual annual cost of power is a nominal sum, it is certainly worth while to ascertain in an approximate way what possible economies can be instituted.

There are many different ways of looking at problems of power plant efficiency, but at the present time the fuel question has to lead in interest. Unfortunately the number of factors which bear directly upon the economical use of fuel is so large, and the interpretation of instrumental data so technical a question if properly handled, that many managers have neither the times nor the training essential to carry through a vigorous campaign against indefinite excesses in coal or gas consumption. It is becoming more and more certain that the analysis of combustion conditions is a task for the specialist, who must be able not only to burn coal in a calorimeter and determine whether or not fuel contracts have been fulfilled on the basis of heat units, but also to report with sound judgment upon the best kind of coal for a given battery of boilers and the proper methods of controlling the actual performance of the grates. In other words, these questions need treatment by the chemical engineer instead of by the mere analytical chemist, and at the present time there is a wide demand for practical ability of this kind based on actual experience in power plant service. Some of the larger electric railways now maintain chemical laboratories in connection with their motive power departments, but central stations have as yet done comparatively little in enlisting the aid of the engineering chemist in their efforts to manufacture power cheaply. Inquiries among many such plants have failed to disclose much appreciation of the broadening field of engineering chemistry in relation to power station operation.

The range of chemical work of an engineering nature desirable in the steam plant includes not only the problems of fuel analysis with respect to calorific power, fixed carbon, ash, moisture, etc., and the study of flue gas temperature, analyses and chimney performance, but the use of the pyrometer in the furnaces and boiler passes, the investigation of the smoke problem, measurement of air supply under forced draft conditions, and the determination of the proper rates of combustion for different styles of grates and stokers. In many localities the boiler feed water is troublesome on account of the presence of scale-forming compounds, and the removal of these, including the analysis of scale chipped from the tubes, is distinctly a chemical problem.

In the producer gas engine plant there is a still more pressing demand for the work of the engineering chemist; for the reactions of the gas-making process, the control of the enriching steam supply, the utilization of residues in case any occur, the proper removal of tar and the determination of the necessary air supply, all call for expert knowledge. The quality of the gas is a matter of constant importance, for if it is inferior, the performance of the engines is liable to be unsatisfactory and the rate of depreciation excessive. The analysis of cylinder residues is suggestive in both gas and steam plants. Scale-forming material or other matter of a corrosive nature frequently gets into the cylinders, and the tendency toward increased wear needs to be carefully examined. It is practically out of the question to get the best results from a modern producer gas plant unless the conditions are watched from the chemical as well as the operating engineer's point of view.

There is a broad field for chemical investigation in both steam and gas plants in connection with the testing of lubricants and bearing metals. The last word has by no means been said upon these subjects, but primarily the engineering chemist is concerned with fuel problems. When a plant exists by the sale of power, it is poor economy to fail to utilize every practicable means of analysis directed toward the betterment of the fuel consumption. Extensive chemical investigations may not be financially possible in small stations, but sometimes several plants in the same general locality can share the expense of the more important studies with mutual advantage. Offhand judgments as to the best operating methods in the boiler or producer room are liable to prove costly in the long run. It is not enough to reduce the coal consumption per kilowatt hour—the effect of changes in the rate of combustion, draft and other conditions on the life of exposed parts of the equipment should also be taken into consideration.

These widening aspects of special lines of science are indications of the passing of that provincial point of view which in older days could not appreciate the common dependence of the different branches of engineering upon the fundamental laws of physics and chemistry, or the mutual professional interests of different technical workers. The modern power plant reaches in its distribution a clientele of the widest individual differences, and it is significant of its expanding utility that its most successful administration requires the services and advice of specialized minds. For many years, attention was fixed mainly on the improvement of apparatus, then it shifted to the selection of apparatus for a given purpose, and now, with the good knowledge in these two lines, investigation is directed to economy in utilizing fuel when suitable plants are provided.

The Square Deal in Specifications.

One would fancy at the first thought that a set of specifications for engineering work could be, and naturally would be, so drawn as to show a fair and clear field for the bids that they are intended to evoke. Of course it is difficult to tie up every detail and provide for every contingency, yet in the main certain well-defined things are required, and it should be possible to embody these so clearly as to leave small room for any mistake. Still, as every contractor knows to his sorrow, such specifications are the exceptions rather than the rule. Sometimes the trouble comes from inability to write plain and unequivocal English, a failing that is far too common even among engineers. Occasionally it arises in ignorance of what is really wanted, the contractor being tacitly charged with the responsibility of determining the real requirements of the case. Either of these conditions can generally be met with fairness to all parties concerned. But there is another class of specifications far too common, in which ambiguity springs from the desire of some one covertly to include conditions which practically will determine the award of the contract to a favored bidder, although the competition remains ostensibly an open one. It is against this particular kind of unrighteousness that a protest is justified whenever it is seen.

If an engineer or owner desires to turn over his work to a particular person or firm he is quite at liberty to do so, and this procedure is at times eminently wise and satisfactory. No obligation rests upon any one not in public office to go out into the open market for the purchase of anything whatever. But if he elects to open his business to general competition, fair dealing requires that he should do so in good faith and that he should require this good faith of any agent who may draw the specifications. No one has a moral right as a decent human being to expose a contractor to serious loss of time and money under false pretenses, by inducing him to bid on a contract the award of which to another is predestined. If, as in most Government contracts, open competition is required by law, then the doctoring of specifications beforehand deserves to be called by an uglier name than unrighteousness. If with due deliberation, a particular thing which can be furnished by one person only, is required, and that thing is openly called for in the specification, the competition is thereby frankly stated not to be open in that particular and no one is harmed. It is only when such a requirement involves the whole contract that there is fair reason for protest, and then only in case the competition is ostensibly open.

The more usual course is to lay out the specification in such terms that all bidders but one will be put at a serious disadvantage in the nature or delivery of the goods. It is a comparatively easy matter to describe apparatus in such terms that it will be standard for one manufacturer and highly special for all the rest or will implicitly involve the use of somebody's patents. This kind of bad faith is sometimes hard to bring home to its perpetrator. Sometimes even doctored specifications go wrong, and then there are still other devious channels open to the commission hunter. There was one large contract for which the specifications were ostensibly quite open but very loose. The wrong man came in with the low bid and after long delay the bids were required to be segregated as regarded important items. Then after further delay new bids were called for under revised specifications adapted to shut out most of the bidders, and finally the contract went to the right man at a price considerably above the original figures. In such cases it is very hard to prove dishonesty although the moral evidence may be very strong. Private business is not exempt from this sort of thing and even supposedly reputable engineers sometimes reach out a crooked hand through unfair specifications. One can have no patience with this sort of sneaking dishonesty. If open competition is undertaken it should be under conditions that give every bidder an equal chance for acceptance, provided his bid is satisfactory and in good faith. Some bids are crooked, like some specifications. If an impecunious grocer's clerk puts in the low bid on a twenty-story apartment house, one is justified in looking behind his certified check, and it is a safe rule to throw out all bids that do not come from the active principals. Fair and open specifications encourage bids of the same kind, and in no other way can one get honest work done.

The New English Coal-field.

There are few developments of mineral resources now being undertaken which show more clearly the intimate relation between geology and mining than the recent work in what is termed the Southeastern coal-field of England, between Dover and Canterbury. While the future of the field is still problematical, and it is by no means certain that the garden land of Kent will be turned into an industrial district like that which has grown up around Liège and Valenciennes since the discovery of coal there in the nineteenth century, still the promise given by the borings already made is considered very encouraging. This discovery comes at a particularly opportune time to quiet the apprehension of a portion of the British public lest the price of fuel will shortly rise by leaps and bounds, owing to the diminution of available supplies. This feeling is the natural result of some of the utterances of eminent scientists, misinterpreted by readers who have not taken the time to examine carefully just what has been said on the subject. While it is true that every dictate of national economy and individual thrift points to the necessity of curtailing waste in mining and burning coal, nevertheless there is no probability that there will be any very marked depletion of British coal supplies for many generations to come.

The development of this new field is largely due to the persistence of Prof. W. Boyd Dawkins and the faith of the late Sir Edward Watkin in the teachings of science. The first geologist to advance the idea that coal could be found under Southeastern England was Godwin-Austen, who read a paper on the subject before the Geological Society of London in 1856. It gives a very interesting example of the exercise of trained scientific imagination to lay bare the secrets of the earth's crust. He explained the origin of the coal measures of South Wales, North Somerset, Belgium and North France, and concluded that there must be coal beds beneath the oolitic and cretaceous rocks of Kent near enough to the surface to be workable. This idea was turned down by the head of the Geological Survey of that date and it was not until ten years later that Godwin-Austen was able to secure a hearing again for his theory. This time he found a believer in one of the members of the Coal Commission of 1866-71, and the report of the Commission was so favorable to his views that funds were raised for sinking a boring at Netherfield, at a point selected by Prof. Dawkins. This first boring went down 1,905 ft. without reaching any coal, but it furnished the information necessary to ascertain where the search for coal could be conducted with better chances of success. Eleven years went by before anything further was done, but in 1886 a boring was started under Prof. Dawkins' direction and with funds raised by Sir Edward Watkin which finally reached coal about 1,100 ft. below Ordnance Datum and revealed thirteen seams of coal in a thickness of about 1,173 ft. of sandstones and shales. Since that time other borings and shafts have been sunk and are now being driven which reveal enough information about the seams to warrant the hope that the twentieth century will furnish England with another valuable coal field.

Those who are interested in this instructive history of geological investigation will find a full account of the subject in a paper read before the Society of Arts on March 6 by Prof. Dawkins. It is the story of a scientific idea, originated many years ago, taking root in the minds of geologists, developed into a theory, and ultimately verified by facts. It is a striking instance of the scientific imagination in advance of the facts, starting from the basis of past experience. The idea has been the center around which the facts have been grouped until, to-day, it appears as a piece of strictly inductive logic without a trace of a priori reasoning. This is not the place to consider the details which the eminent geologist gives in his valuable paper, but the mere facts themselves are highly instructive. It is now known that at a depth of approximately 1,100 ft. below Ordnance Datum the first beds of good coal are encountered; they are found well within the limits of depth at which it is profitable to work coal and extend over a considerable area. The overlying rocks do not present as serious obstruction to shaft sinking as some of those overcome elsewhere in England, and the amount of water to be encountered does not seem to be great. The deepest working shaft now sunk is down only a little over 400 ft., so it is still too early to know definitely whether the Kent coal fields will be commercially profitable, but those who have looked into the subject have every confidence in the successful outcome of the venture and equipment for working on an extensive scale has already been purchased. If it proves successful and a new coal field is added to the mineral resources of a country so well studied geologically as England, the result will be encouraging to those who believe that American coal resources are by no means well known as yet.

Notes and Comments.

The Raising of the Assuan Dam, ordered by the Egyptian Government last month, will doubtless result in a whirlwind of protest from archæologists and architects, for it entails the submersion of the famous temples of Philæ. It is of course a matter of great regret that this must be done, but a consideration of the facts will show that no other step is possible in the face of the country's needs. The dam was designed by Sir William Willcocks so that it could be raised 6 meters above its present height and still have a cross-section far heavier than most masonry structures. One of the reasons which led to stopping the work at the present height was the strong popular clamor to save the ruins at Philæ, but the government constructed the portion of the dam first built heavy enough to permit the additional height to be added later. Since then it has been making a careful survey of the Nile valley between Wady-Halfa and Khartum to ascertain whether it were possible to build other reservoirs which would give results at all comparable with those to be obtained by raising the Assuan dam. The difficulties attending the erosion of the bed below the dam and the controversy which arose when the Pearson-Atcherley theory of stresses in masonry dams was published have given the government plenty of time to make a thorough investigation of the problem of securing additional water. The alternative presented to it by all its investigations was either to retain the ruins at Philæ in their present condition or to submerge them by raising the Assuan dam 7 meters and thus obtain water enough to bring under cultivation nearly a million acres of land in Upper Egypt, which must otherwise remain barren through lack of water. The increased value of the annual cotton crop which this irrigation will produce is estimated at £3,500,000 to £4,000,000, while the total cost of the work is estimated at only £1,500,000, including compensation to the owners of land in Nubia which will be surmerged. The government's decision is therefore one which would have to come sooner or later, however much the world must regret to see the best monuments of Egyptian art disappear. Apparently nothing can save them unless a few wealthy men interested in art and architecture furnish funds for the removal to some other spot of at least the more important objects. This removal was once asserted to be impracticable, but it is understood that it is practicable if reasonable care is taken in the work.

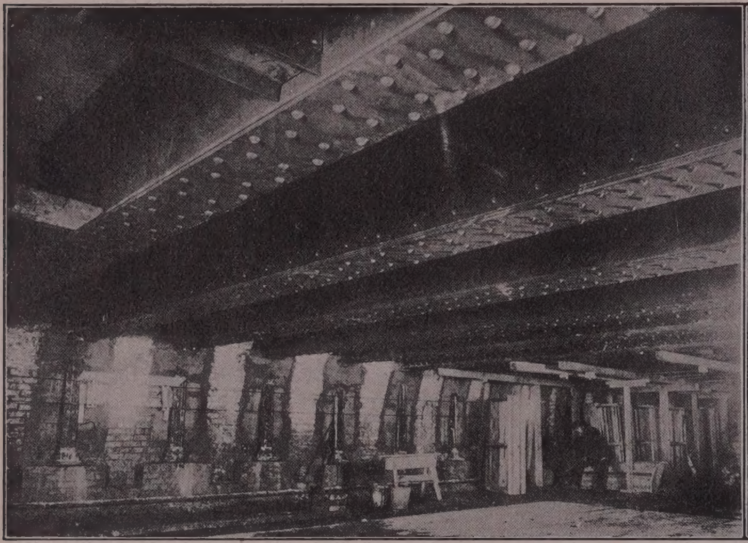
The Irrigation Works undertaken by the Reclamation Service are feeling very seriously the effect of the extraordinarily high prices for materials and labor which rule throughout the West, and it would not be surprising if it were necessary to curtail these enterprises until conditions become normal again. The Service is experiencing difficulty in securing bids for work at estimated rates, owing to the other opportunities which contractors have, and in some cases work has been advertised several times without obtaining bids which it was considered good policy to accept. The alternative of executing the works by force account or abandoning them must therefore be faced. When it is considered that there is an unusual scarcity of labor in the regions where the Service is operating and wages are 40 to 60 per cent. higher than two years ago, the difficulties of organizing a large force of efficient men in places remote from cities is apparent. The Government stands to get only the rifraf of the labor market. It has to pay nearly double what it did two years ago for cement, lumber, horses and mules. As a result the cost of earthwork excavation has run up from an average of 13 cents to 27 cents per cubic yard and reinforced concrete from an average of $8.50 to $18.50 a cubic yard. Shipping facilities are also causing a great deal of trouble, as is shown by the experience of a contractor who ordered a shipment in November. It was loaded on the cars then and a man detailed to follow the car and expedite early delivery in every way possible. Notwithstanding all these precautions, more than three months elapsed before the materials were received at their destination only a few hundred miles away. The great increase in construction expenses has made it necessary to revise the estimates on all the large projects of the Service, and it is understood that any further increase may render some of them so expensive that difficulty will arise in disposing of the lands irrigated at prices attractive to settlers.

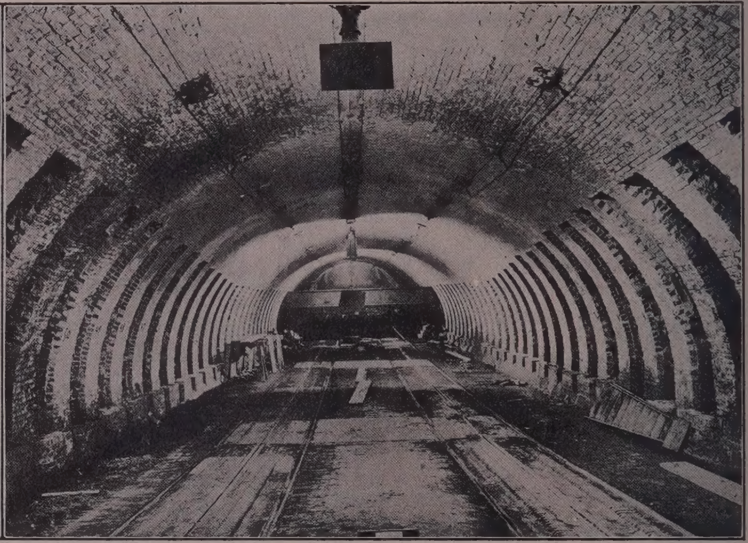
Great Canal and Land Improvements are outlined in a bill introduced recently in the New Jersey Legislature. While the late date at which this bill was handed in makes it hardly possible for any consideration to be given to it during the present session, the general scheme is so interesting as to deserve a few words of comment. It is well known that the present facilities for manufacturing on the water front or near it at the port of New York are rapidly becoming overtaxed. The largest undeveloped tract of land which is available for manufacturing purposes is what is known as the New Jersey Meadows, lying west of Jersey City and extending nearly to Newark. This great tract of marsh land is intersected by two streams, the Hackensack and the Passaic, both discharging into Newark Bay. For many years it has been recognized that the improvement of this meadow tract by works which would not only drain the land, but also furnish fairly deep navigation were very desirable. Already manufacturing establishments have moved from the crowded portions of New York to the meadows, the most noticeable of these being the plants of the International Steam Pump Co. In order to develop this land properly and to furnish the city of Newark with the navigation facilities that are desirable for its large manufacturing interests, it is proposed in the bill now before the Legislature to give the city the right to build a great canal 1,000 ft. wide through the meadows from Newark Bay into the city, and to condemn land on both sides of the canal on which railroads could be built and other facilities afforded for developing this property in the manner which is necessary to make the project successful. The project is an enormous one, probably larger than the city can undertake unless it sets itself resolutely to the task in the same manner that Manchester undertook the construction of the famous ship canal which has made it a seaport. Newark is a city big enough for this work, if it cares to undertake it.

The Criticism of Steel Cross Ties made by the officials appointed to investigate the wreck on the Pennsylvania R. R. at Mineral Point has attracted so much attention that it is desirable to point out just exactly what the board said. The wreck occurred on a section of line laid with experimental Carnegie steel cross ties. The track was on a curve of 3¼ deg. and was torn up a distance of about 1,200 ft. The high rail was found clear of the ties on top of the embankment. The outside bolt fastenings had been sheared and snapped off the entire distance of 1,200 ft. As evidence of the force with which these bolts were broken off, some of them were found about 200 ft. from the track. The steel ties were badly crushed. The inside clip on the low rail had been badly damaged by the derailed wheels and these had also broken pieces out of the base of the rail at intervals, although it was not thrown out of its original position. At the point of the accident the first splice bar ahead of the point of derailment on the high side was broken through the second bolt hole and bent outward by a lateral thrust. The evidence shows that the train was moving at not more than 50 miles an hour at the time the accident occurred. When the track was examined by the board a portion of it had been renewed with wooden cross ties and was in service. The board made a careful inspection of the track of steel tie construction for a distance of about half a mile ahead of the portion damaged by the wreck, which was not affected by it, It reports that this track was in first-class condition, all of the outside clips being tight against the base of the rails and the bolts on the inside, with few exceptions, being tight, holding the clips in position. The line and surface was as nearly perfect as possible, and the whole mass of steel cross ties was frozen tight to the ballast. There was not the slightest indication of shifting in any direction, nor was there any indication of movement on the top of the steel cross ties by any of the rails throughout the entire distance. The preceding statements are substantially those given in the board's report, nevertheless the conclusions drawn by the latter read as follows: "If the accident had occurred on the section of the track laid with wooden cross ties, it is our judgment that less injury would have been done to the track structure. . . . We are of the opinion that on account of the lack of positive evidence as to the cause of this derailment, and on account of the fact that the damage subsequent to the derailment was more serious than would have been the case with wooden ties, that the remaining steel ties should be removed." It is apparent that some of the steps in the reasoning by which this conclusion was reached have not been made public, for it is hard to see the logical connection between the statement of facts and the conclusion.

PROGRESS IN LOWERING THE TUNNELS UNDER THE CHICAGO RIVER.

The lowering of the roofs of the two street railway tunnels under the south branch of the Chicago River, at Van Buren and Washington Sts., in Chicago, has progressed far enough to indicate that this work will be completed soon after the opening of the coming navigation season. The Washington St. tunnel is about 1¾ miles, and the one at Van Buren St., 2¼ miles from the mouth of the Chicago River in Lake Michigan. The former tunnel is owned by the city, but up to the time it was temporarily abandoned it had been used for 20 years exclusively for street railway traffic by the Chicago Union Traction Co. The Van Buren St. tunnel, which was built and is owned by the Chicago Union Traction Co., was also used exclusively for street railway traffic. The top of the existing roof of the Washington St. tunnel is only 17 ft. below Chicago datum, or 16 ft. below the mean water level in Lake Michigan; the roof of the Van Buren St. tunnel is 18 ft. below Chicago datum. The fluctuations in the stage of the river due to changes in the water level in Lake Michigan and the slope of the surface of the water from the mouth of the Chicago River to the tunnels, since the flow in that stream has been reversed by the opening of the Chicago Drainage Canal, reduce the depth of water over these tunnels to 15 and 16 ft., respectively, under present conditions.


Bottom of New Roof Girders, Van Buren St. Tunnel.


Chases in Old Masonry, Van Buren St. Tunnel.

The depth of water over these tunnels and a depth of only 16 ft. at times over a third tunnel under the main branch of the Chicago River at La Salle St., 1¼ miles from Lake Michigan, have limited the vessels entering the river to smaller craft, thus unquestionably affecting the lake commerce of the city. In April, 1904, Congress ordered the removal of the tunnels so 22 ft. of water would be provided over them the full width of the river, by April 15, 1906. After various delays the time of completion of the lowering was extended to April 1, 1907.

The Union Traction Co. undertook the expense of lowering all three tunnels under an agreement with the city. The plans and specifications under which the contracts were awarded were prepared by Mr. Samuel G. Artingstall as engineer for that company. A brief description of the plans for lowering the La Salle St. and Washington St. tunnels was published in The Engineering Record for July 21, 1906.

All three tunnels were built of brick masonry. The La Salle St. tunnel, which was finished in 1870, had three parallel longitudinal divisions under the river, which were separated by the longitudinal bench walls of the brick arches over the divisions. One of the latter was built for a footway, but had been practically abandoned as such and was given up almost entirely to cables, wires and water mains; the other two divisions each carried a street railway track. The Washington St. tunnel was built in 1869 and was originally arranged in the same manner as the one at La Salle St. The river section of this tunnel was rebuilt in 1889, when the wall between the two longitudinal divisions carrying the car tracks was removed, a new roof was built and the footway abandoned. The tunnel at Van Buren St. was built in 1892 and had a three-centered brick arch over a single longitudinal section carrying two street railway tracks.

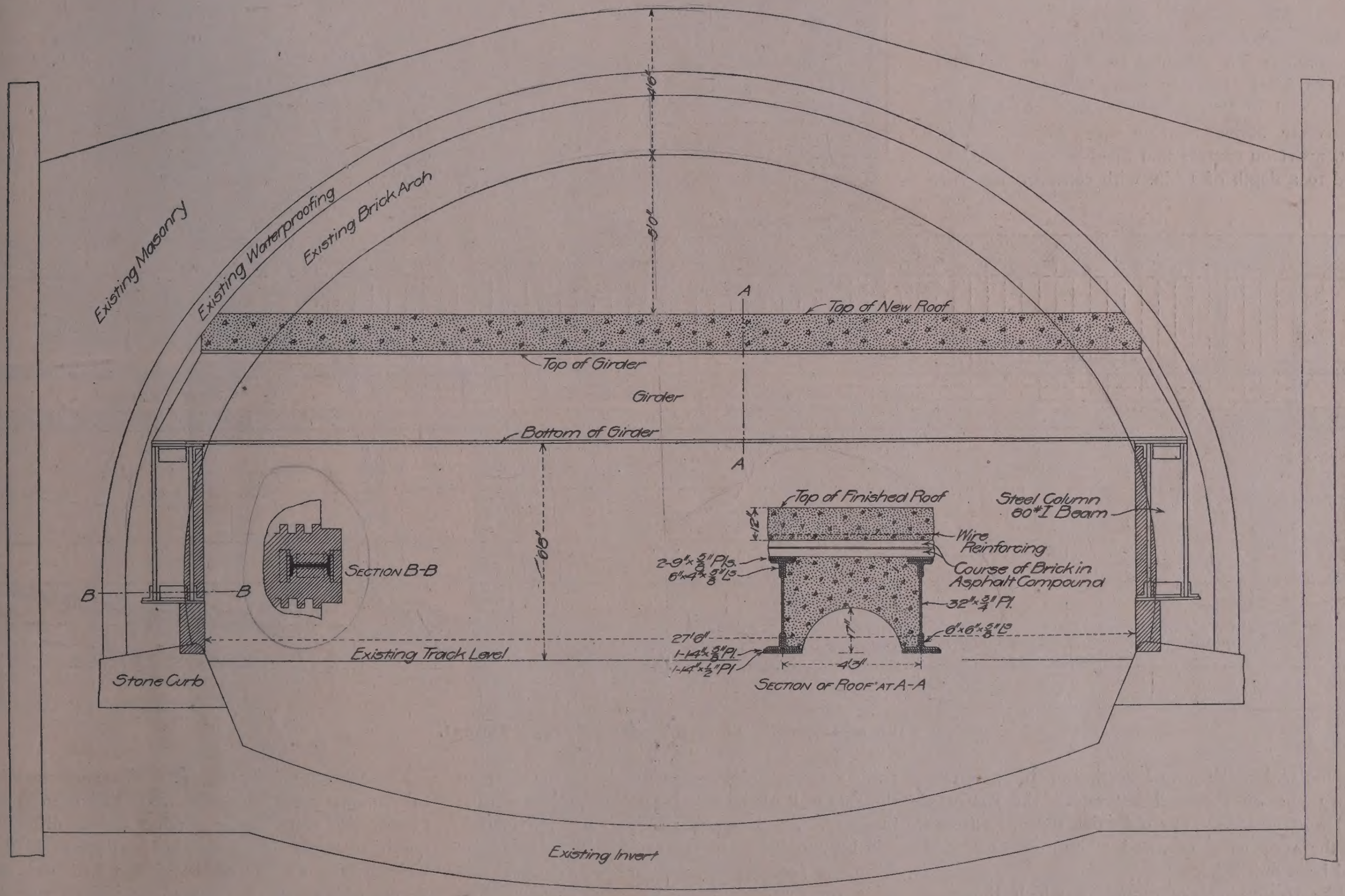
The general plans for lowering the roofs of all three tunnels contemplated the construction of a new flat roof within the river sections of the tunnels, with the top of the roof in each case at the necessary distance below the surface of the river to provide the required depth in the latter. After this roof has been constructed and made watertight with the side walls of the tunnel the old roof and side walls were to be removed down to the level of the top of the new roof. Work had just been started on the La Salle St. tunnel when leaks developed in the masonry and the tunnel was abandoned. The roof of this tunnel is now being blasted off with dynamite to remove the obstruction offered to river traffic by it. The work of lowering the roofs of the Van Buren St. and Washington St. tunnels has progressed very satisfactorily, however, and is about 70 per cent. finished on the former, and 60 per cent. on the latter, with every indication of successful completion in both cases.

The Van Buren St. tunnel was built in 1889-92 by the West Chicago Street Railway Tunnel Co., of which Samuel G. Artingstall was chief engineer. It is a three-centered arch of seven courses of brick covered with concrete, and is 30 ft. wide, 20 ft. high and 1,502 ft. long between portals. The first five courses of brick were laid in Utica cement mortar while the remaining two courses were laid in asphalt compound and formed a waterproof course. The brick arch was covered with a Portland cement concrete 2½ ft. thick at the crown and extending down into the cofferdam as shown in the accompanying cross section. The inner row of piles of the cofferdam were driven as close together as possible and were afterwards cut off about 12 in. below the top of the concrete. The invert of the present tunnel was built on a radius of 36 ft. and is 2 ft. thick along the center line of the tunnel. The 500-ft. length of this tunnel on the west side of the river is under the yards of the Pennsylvania R. R., and the 300-ft. length of the tunnel east of the river section is under two 8-story buildings which are supported by the tunnel.

The position of the new roof relative to the existing masonry is shown in the cross-section. This roof has a length of 220 ft. and a total thickness of 4 ft. 6 in., and is built of concrete and heavy transverse steel girders carried at each end by a steel column resting on the masonry of the old tunnel. These girders are 32 ft. long over all and are spaced 4 ft. 3 in. apart on centers. They have an I-shape section and are built up as shown in the detail section. The columns carrying the ends of the girders are 15-in., 80-lb. I-beams, which are seated on brick masonry piers built up to the springing line of the arch and are placed in chases cut 2 ft. deep into the brick side walls of the tunnel. The space between the girders is filled with concrete which is carried up so as to cover completely the rivets on the top flange of the girders, a jack arch being formed between each pair of girders. Over this concrete is placed the waterproofing of the roof which consists of a ½-in. layer of asphalt compound. On this asphalt while it was still hot, was placed a course of brick, laid flat with about ½-in. joints. The joints between these brick were filled with asphalt, enough of the latter being used to fill the joints and cover the brick to a depth of ½ in. The original plans called for a 15-in. layer of concrete to be placed over this course of asphalt, but no bond could be obtained between the asphalt and concrete. The asphalt compound, however, could not be separated from the brick with a crowbar, so a second course of brick with 1½-in. joints was laid in the hot compound and the joints then flushed with a rich grout which was immediately covered with 12 in. of concrete; strips of wire fencing were embedded in the latter to tie the mass together.

The invert of the tunnel will have to be lowered 8 ft. in the section under the river, and the walls of the tunnel underpinned to that depth. From the river section the underpinning will gradually decrease toward each portal, where it will again take the same grade as the present foundations. In other words, the underpinning will have a triangular shape with a depth of 8 ft. at the dock lines and a length of about 500 ft. along the line of the tunnel. This invert lowering will all have to be done in narrow sections and at different parts of the tunnel so as to give each new section a considerable time to set before the adjoining section of old invert and foundation is removed.

The contract for lowering the roof and the invert of this tunnel is being carried out by the Great Lakes Dredge & Dock Co., of Chicago, under the supervision of Mr. Thomas Osborn, of that company. The first work done in building the new roof was to cut the chases in the side walls of the tunnel. The original intention had been to cut every fourth chase at first, then to erect the roof girders in these chases and to block up the brick masonry over the latter before cutting additional chases. The steel girders being delayed in delivery, this order of work was changed and about half of the chases were cut before any of the girders were erected. The chases were 2 ft. wide and extended 2 ft. into the brickwork. They were cut from the top of the piers for the columns carrying the roof girders up to a point 1 to 2 ft. above the grade of the top of the new roof. As the girders occur every 4 ft. 3 in. and a 2-ft. chase had to be cut for the end of each one, the piers between the chases were only 2 ft. 3 in. wide. The remaining masonry proved to be entirely strong enough, however, to carry safely the load on the tunnel roof.



Typical Cross-Section and Details of the Van Buren Street Tunnel.

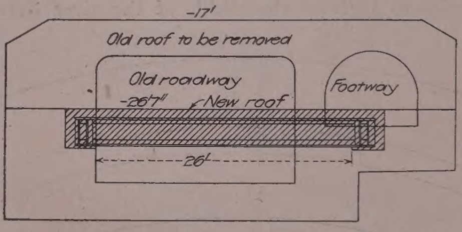
The I-beam columns were set on base plates and after the roof girders were erected the latter were riveted to the columns. The girders weigh 4.5 tons each and were delivered to the work ready to be erected. They were brought down into the tunnel on a low four-wheel flat car running on one of the old street car tracks, and were skidded around and jacked up into place from this car. The extremely limited available head room and the fact that both ends of each girder extended 2 ft. into the brick wall from the face of the latter, greatly handicapped the placing of these girders. As the girders were erected the remaining space in the chases around the columns was filled in with concrete. The forms were then set for the jack arches in the concrete between the pairs of girders and the placing of this concrete started. The concrete was mixed by hand in the limited space between the lower flanges of the girders and the old track level and was hoisted up over the girders through a space obtained by omitting one of the jack arches near the middle of the tunnel. After this concrete had been placed the two courses of brick were laid over it in the asphalt, care being taken to make a good joint in the chases with the waterproofing course in the old masonry which had been exposed in cutting the chases. On the completion of this waterproofing course the top 12-in. layer of concrete was laid over it, the layer being made continuous back to the old waterproofing in the chases.

Solid brick bulkheads were built over the ends of the new roof up to the old tunnel arch. In order to increase the width of the river over the tunnel so as to reduce the current caused by the opening of the Chicago Drainage Canal, a side channel, 50 ft. wide, was built under the railroad yards over the west end of the tunnel. In the future the main channel of the river will be widened to include this side channel, so in lowering the tunnel roof provisions had to be made for sustaining the present masonry dock along the river and also to provide for this eventual widening, which was accomplished by constructing two bulkheads over the west end of the new roof. These bulkheads are each about 13 ft. thick and are separated by a course of dry brick, in order that the section under the masonry dock may be removed when the river is widened. The bulkheads are all thoroughly keyed into the existing brick arch.

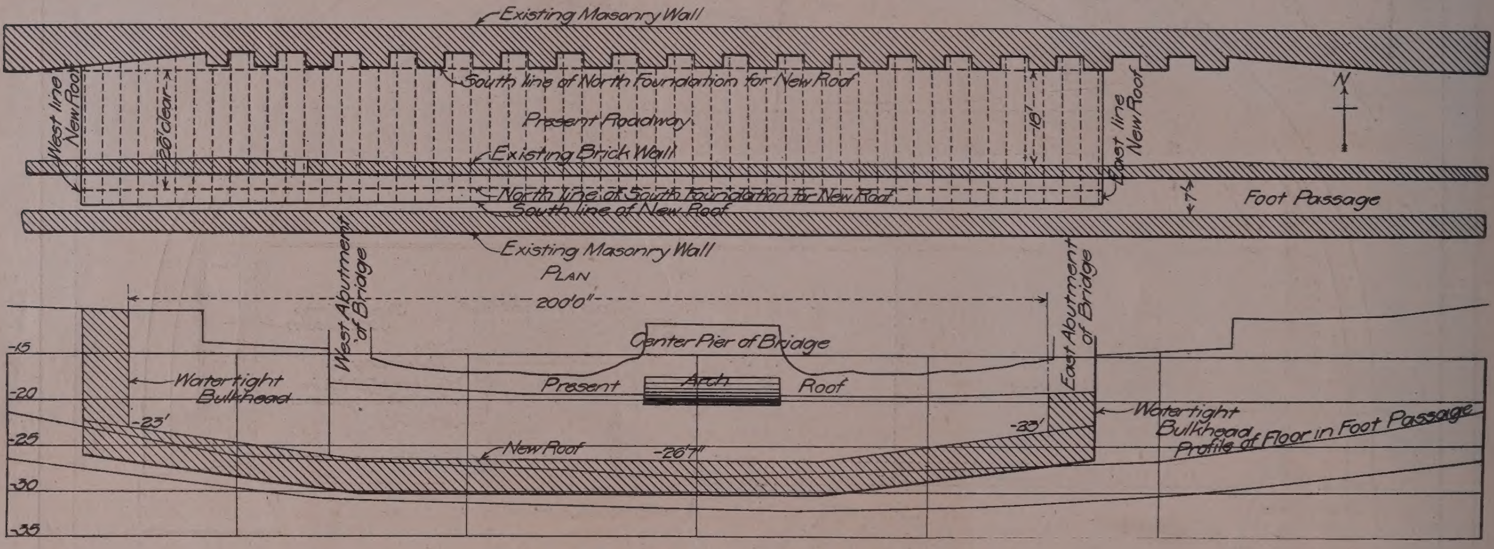
The specifications covering the removal of the masonry of the old tunnel arch down to the line of the new roof in the tunnel required that the masonry be destroyed as much as possible from the under side after the new work had been made tight. Accordingly, after the portion of the top layer of concrete in the new roof extending into the chases in the side walls had hardened the masonry of the tunnel arch was blocked up in this concrete and the tops of the brick piers above the top of the roof and between the chases were cut away. A line of cleavage, 2 ft. deep and about 2 ft. high, was thus left in the old masonry along each side of the arch and directly over the new roof line.

At the time this article was prepared none of the old roof had been removed, although the plans for that work were fully developed. The specifications required that the space between the new roof and the old tunnel be completely filled with earth or other material to act as a cushion which will protect the new roof during removal of the old masonry. The latter is also required to be removed without the use or aid of cofferdams or explosives and in such a manner as to avoid as much as possible any jars or concussions which would injure the new construction. The cushion of sand has been placed over the new roof as required and preparations are being made for the removal of the old masonry arch. The latter work will be done with the assistance of an ordinary rock channeling machine set up on a scow in the river. Cuts will be made transversely across the arch about 4 ft. apart at one side of the river, with this channeler. This strip of old masonry will be broken out, the lines of cleavage on the inside of the arch being expected to assist materially in causing it to break readily, and then successive strips will be cut off in a similar manner across the channel, the loosened material being removed with a dredge.

The lowering of the roof of the Washington St. tunnel has to be carried on in a manner entirely different from that followed in the one at Van Buren St., owing to the necessity of carrying the former tunnel's present flat and com-



Cross-Section Washington St. Tunnel.



Plan and Profile of Washington Street Tunnel.

paratively light roof, together with the load of water on the latter, while the new roof is being built within the tunnel. The present roadway in this tunnel has a clear width of 18 ft. with a clear height of 12 ft. from the top of the rails of the street car tracks in this roadway to the lower side of the flat roof. At one side of this roadway and separated from it by a 3-ft. brick wall, is a foot passage 8 ft. wide and 10 ft. high. The original river section of the tunnel had three parallel separate longitudinal divisions; two of these, each 11 ft. wide, were provided for vehicular traffic, and the third was the foot passage. The three divisions were separated by a 3-ft. wall through which openings were made to assist ventilation. The tops of these divisions were brick masonry arches, the adjacent arches sharing the same footings. A waterproof course consisting of some kind of tar product was placed over the tunnel. When the tunnel roof was rebuilt in 1889, the wall between the two divisions of the roadway was removed and the width of the roadway was reduced to 18 ft. by the addition of brick masonry along the inside of the north wall of the tunnel. A roof consisting of transverse 20-in., built-up steel girders, spaced 3 ft. apart on centers and filled between and covered to a depth of 12 in. with concrete, was then erected within the tunnel, resting on the new masonry and on the wall separating the roadway and foot passage. The old brick masonry arches of the roof were removed when this new roof had been finished.

The section of the tunnel in which the roof was lowered in this manner was 146 ft. long. Over the ends of this roof were erected the two masonry abutments of a center pier drawbridge carrying Washington St. over the river, the masonry center pier of the bridge being built on an arch at the middle of this lowered section. The new roof has a total length of 220 ft., and extends from under the land side of the east abutment of the bridge over the river, to 65 ft. beyond the west abutment of that bridge. The present width of the river will soon be increased to 200 ft., so that the lowered roof will extend entirely under the proposed channel and 10 ft. beyond each side of the latter, thus providing space at each end for a 10-ft. water-tight bulkhead over the new work extending up to the masonry of the old tunnel roof. A section of this new roof, 100 ft. wide, at the middle of the channel will have its top 26 ft. 7 in. below Chicago datum, giving 26 ft. of water in the river. From each end of this 100-ft. section the new roof rises on a flat slope until at the dock lines along the sides of the channel it is 23 ft. below Chicago datum.

The old foot passage along the side of the tunnel was abandoned some years ago so it will be torn out and the width of the roadway increased to 26 ft. in the clear by the construction of the new roof. The details of the latter are quite similar to those of the new roof in the Van Buren St. tunnel. The roof consists of steel girders 2 ft. 6 in. deep and 30 ft. long, which are placed transversely across the tunnel, 4 ft. apart on centers. The spaces between these girders are filled with concrete and the girders are covered over the top to a depth of 1 ft. with a course of waterproofing and concrete, making a very heavily reinforced flat concrete roof, 5 ft. thick. The girders have an I-shape section with a 29¼ x 11/16-in. plate forming the web and two 5x4x½-in. angles and a 11x¾-in. plate the upper and lower flanges. The girders at one end extend 2 ft. into the old brick masonry of the side wall of the tunnel and are carried by that masonry. At the other end they extend through and beyond the 3-ft. wall separating the roadway from the foot passageway and have a seat 2 ft. wide on masonry built to receive them. The course of waterproofing is continuous over the top of the girders and the concrete in which the latter are embedded and extends down at both ends of the girders to 4 in. below the bed plates.

The new roof is being constructed and the old masonry will be removed by Angus Bros., of Chicago, under the direction of Mr. Paul Wurster, superintendent. As the existing roadway was 18 ft. wide and the girders of the new roof are 30 ft. long, considerable difficulty was experienced in placing these girders. Much of the old masonry in the walls had to be cut away and as these walls carry directly the existing roof of the tunnel, it was necessary to shore them carefully as rapidly as they were cut under. The lower flanges of the steel girders only clear the old tunnel floor from a few inches to 2 ft. A chase, 2.5 ft. wide and 4 ft. high was cut for each girder in the outer tunnel wall on the opposite side from the footway; an opening of about the same size was also cut for each girder in the wall between the roadway and the footway. The old masonry of the footway and in places a part of the footing for the outer wall on that side was taken out down to the level of the seat of the end of the girder on the old masonry at the same time, so that the girders have a clear span of 26 ft. The girders were placed in succession, beginning at the east end of the roof, and only a small part of the walls at one point were unsupported at a time. The girders weigh about 3.5 tons each and were delivered into the tunnel on heavy trucks from which they were brought to position and lifted into place with rollers and jackscrews. As soon as a girder had been seated the remaining portions of the outer wall of the tunnel directly above it and the part of the division wall between the footway and the roadway were shored with jack screws. When the girders had been placed and the walls shored up from them, the alternate piers of the old masonry which had been left between the chases were removed one at a time and the concrete filled in between the girders to the full length of the new roof. Timbers were first placed across the girders under the unsupported portions of the walls and the latter were jacked and shored up from these timbers until the concrete had set sufficiently to carry the load, when the jacks were removed, the timbers taken out and the walls shored directly from the concrete and girders.

The placing of the concrete was continued in this manner until the entire roof had been completed, the work being carried on at different points to avoid any danger of settlement in the walls. After several of the girders had been set a row of shoring was placed near each side of the roadway and part of the load on the roof of the tunnel was transferred to the new girders by drums and jacks. This shoring was continued through most of the tunnel before the concrete work was started and the old masonry supports of the existing roof largely cut away. A considerable length of the dividing wall between the roadway and the footway was also largely shored on needle-beams set through holes cut in the wall and carried at each end by jack screws and drums placed on the new girders. This whole dividing wall was finally supported on these needle beams and on jack screws. As this wall carries an estimated load of 22 tons per linear foot in addition to a concentrated load of part of the 350-ton-masonry bridge pier on the middle of the tunnel the shoring had to be very carefully done to avoid injury to the existing masonry. The inner 3 ft. of the opposite tunnel wall was also carried by shoring and jack screws set on the new work. This shoring was done by the H. Sheeler & Sons Co., under a sub-contract from Angus Bros.

The course of waterproofing over the top of the concrete in which the girders are embedded extends vertically down along the ends of the girders and necessitated that the old masonry be cut away far enough back to permit the waterproofing to be placed after the girders had been set. A number of cable conduits were placed in concrete in a space 2 ft. wide by 4 ft. high cut out of the masonry along the inside of the base of the tunnel wall, the floor of the foot passage being cut out to provide this space. An open vertical space 5 in. wide was left between these conduits and the concrete in which the girders are embedded. This space was filled with a course of brick laid in a mixture composed of asphalt, limestone dust and Portland cement which were varied in proportion to suit conditions and were heated to about 350° Fahr. before being applied. The masonry of the wall on the opposite side of the tunnel was cut back far enough after the girders were set to permit the same kind of a vertical course of waterproofing to be applied after the concrete work set was finished. The course of waterproofing was continued over the top of the roof, a course of brick being laid flat in a ½-in. layer of the asphalt compound and the joints between the brick flushed and the course covered with the compound.

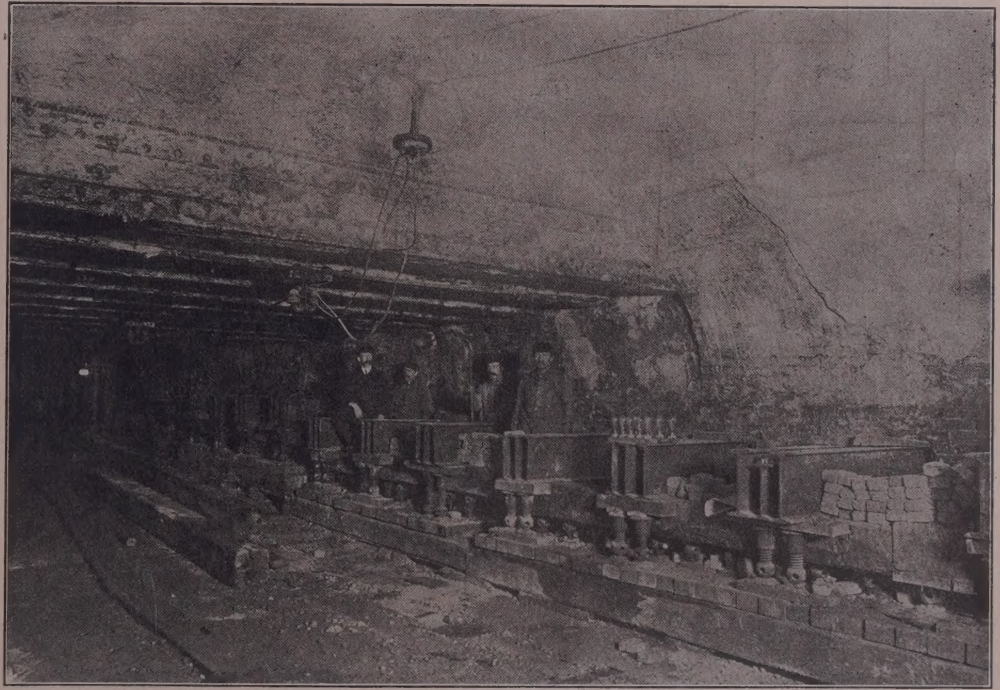
The possibility of vessels in the river striking the existing roof of the tunnel while the new work was being done necessitated that the jacks and the shoring be replaced by permanent underpinning until the new roof was completed. In order to accomplish this the jacks resting on the concrete between the girders and carrying directly the part of the outer tunnel wall which had been cut away were replaced between each pair of girders by a concrete pier and the load transferred to these piers by brickwork.

The jacks which rest on the girders between the small piers already built will be replaced in sections in the same manner so when the new roof is completed the old roof will be sustained by solid masonry which will be removed later with the old masonry. The dividing wall between the roadway and the footway will be similarly underpinned, pending the completion of the new roof and of the bulkheads over both ends of the latter. The two longitudinal rows of shoring toward each side of the roadway will likely be left in place until the new work has been completed.

Tentative plans have been developed for removing the old tunnel masonry above the new roof after the latter has been made water-tight. Lines of cleavage will be cut in the tunnel walls just above the new roof line and the old masonry may be weakened in other places. The space between the new roof and the old masonry above it will then be filled with clay and soil to act as a cushion and the balance of the operations will be carried on from the surface of the water. As the old roof is comparatively light it is believed no great difficulty will be experienced in removing it. No definite plans have been made as yet as to when the invert of the tunnel will be lowered so that it can be used for street railway service again.

Mr. Samuel G. Artingstall was engineer in charge of the lowering of the three tunnels until recently when he was succeeded by Mr. J. Z. Murphy, chief engineer of the Chicago Union Traction Co. The work on the La Salle St. and Washington St. tunnels is being done under the supervision of Mr. John Ericson as consulting engineer for the city of Chicago. Mr. William Artingstall, principal assistant engineer, is in charge of the work on all three tunnels. Messrs. Robert W. Hunt & Co. are inspectors of the work for the street railway company.

Partially Shored and Underpinned Masonry. Washington St. Tunnel.



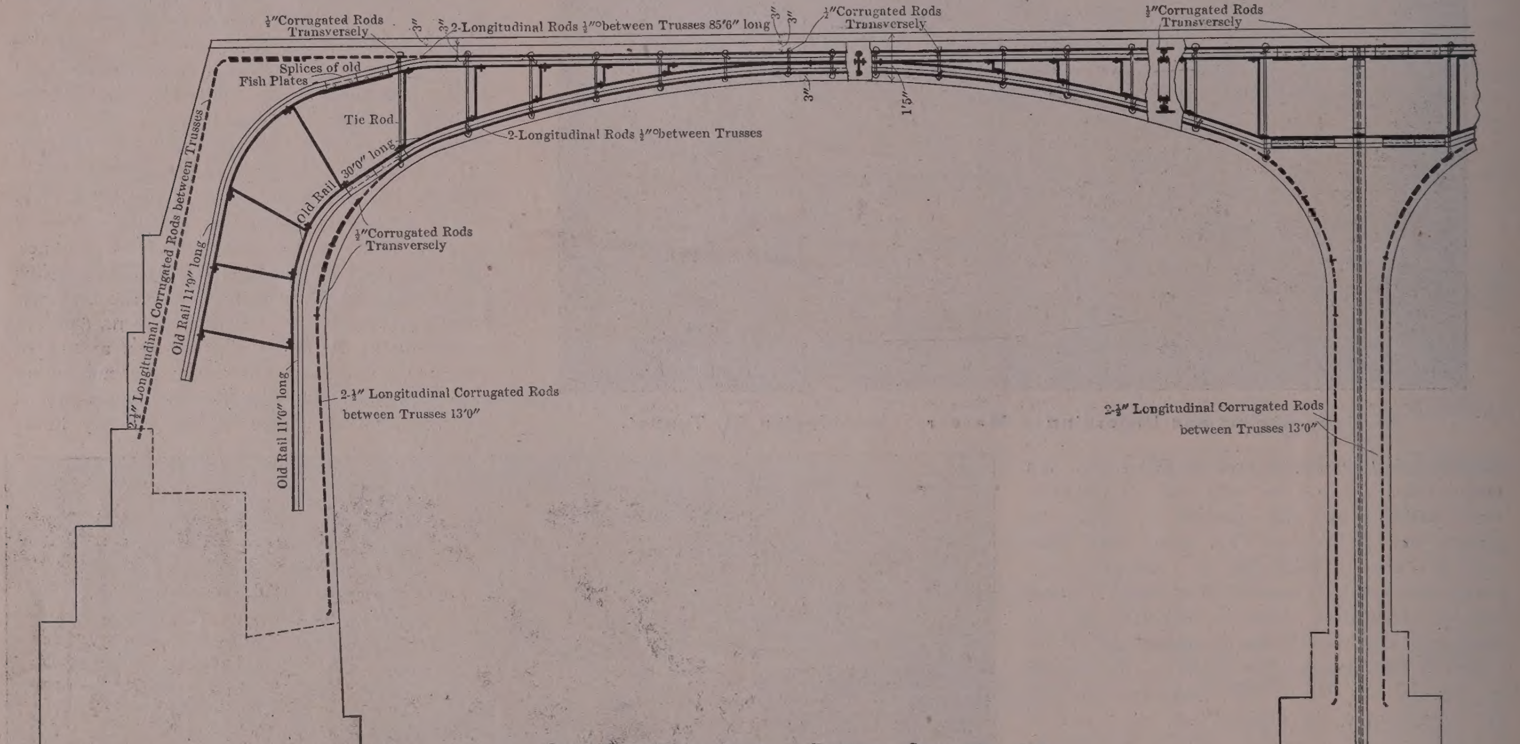
Part of Foot-Passage Wall Shored on New Roof, Washington St. Tunnel.

The Cut Improvements of the New Haven R. R. at New Haven.

During the past year the New York, New Haven & Hartford R. R. has been making improvements through New Haven in what is known as "The Cut." The old line, consisting of two tracks, carried the entire traffic of the railroad through the city, as well as the switching between the Belle Dock and Water St. yards. The large number of train movements, about 350 in 24 hours, caused frequent delays and annoying congestion of traffic at both ends of the cut. In addition the clearances beneath the bridges which carried the streets of New Haven over the tracks was not sufficient for present needs, and the frequent flooding of the roadbed due to an inadequate drainage system added another factor in hastening the improvements. To solve all these problems the cut is being reconstructed on a new alignment, the number of tracks is being increased, the grade lessened, new bridges with greater clearances being built, and an adequate drainage system is being installed. The work was begun about a year ago, and will probably be finished before the close of the present year.

When the improvements are completed there will be 4 tracks the entire length of the cut, about 6,500 ft., and 6 tracks for part of the distance. The new roadbed will be from 2 to 8 ft. below the old one. During construction the traffic is being maintained over the old alignment, and will be thrown to the new tracks as soon as two of them are completed. The excavation, amounting to 350,000 cu. yd., is being done by steam shovel, and the spoil is hauled beyond the city limits and used for filling trestles and widening the roadbed. In order to avoid a series of humps in State St., which parallels the alignment about 200 ft. north of the right of way, the new tracks are being thrown south of the old ones, and as a consequence the bridge approaches do not affect the aforesaid street. The new work reduces the maximum curvature from 7 to 4 deg., the maximum gradient to 0.73 per cent., eliminates 59 deg. of curvature and shortens the line slightly.

The elevation of the completed roadbed will be but slightly above mean high water level in the New Haven Harbor, and since the underlying strata is very porous, consisting of sand even to the limit of borings, about 130 ft., the drainage of the cut presented a serious problem. Under present conditions flooding by high water and heavy rains is not infrequent, and the consequence of lowering the roadbed from 2 to 8 ft. below the present elevation, would have serious consequences unless an absolutely reliable drainage system were installed. To provide for rapid drainage the cut has been divided into two sections, the eastern one draining by gravity into Mill River, the western one by a combination of gravity and pumping into New Haven Harbor. The water is collected by cross-drains extending the full width of the cut at intervals of about 300 ft. These discharge into concrete manholes which lead to the cast-iron pipe drains. The latter increase in size toward the outlet from 16 to 36 in. At the western end of the cut at Water St. the 36-in. drain enters a concrete chamber fitted with tide gates, which operate automatically. In low water the run-off passes directly through the chamber by gravity and on into the harbor. When the rising tide closes the gates, the flow is diverted into a sump, from which pumps force it against the rising head.


½"Corrugated Rods Transversely
2-Longitudinal Rods ½"○between Trusses 85'6" long
½"Corrugated Rods Transversely
½"Corrugated Rods Transversely
Splices of old Fish Plates
Tie Rod
3"
1'5"
2-Longitudinal Rods ½"○between Trusses
Old Rail 30'0" long
½"Corrugated Rods Transversely
2-½" Longitudinal Corrugated Rods between Trusses
Old Rail 11'9" long
Old Rail 11'6" long
2-½" Longitudinal Corrugated Rods between Trusses 13'0"
2-½" Longitudinal Corrugated Rods between Trusses 13'0"
Engineering Record

Arch Reinforcement of Bridges Over the Cut.

The sump, which is built of concrete, is surmounted by a concrete pump house, which contains the motors and switchboards for operating the pumps. The latter are started and stopped automatically by floats, which operate trip switches. When the water in the sump rises to a certain level one of the pumps is started, and should this prove inadequate and the water rise another foot the second pump is thrown into service. As an additional precaution a tell-tale connecting with a bell in an adjoining switch tower gives warning of a flooding of the sump. This effectually prevents the flooding of the cut due to the accidental stoppage of one or both of the pumps. The run-off has been calculated for a maximum rainfall, assuming the ground to be frozen. The pumps are of the vertical submerged type with a rated capacity of 6,000 gal. per minute against a head of 10 ft. They are driven through bevel gears by 50-h.-p. direct-current motors. The entire installation was designed by Westinghouse, Church, Kerr & Co.

The sides of the cut are lined for almost its entire length with concrete retaining walls, except where business buildings are built up to the edge of the right of way. The front face has a batter of ½ in. to the foot, and the back face is stepped and projects 6 ft. beneath the abutting property, the property line being coincident with the fence surmounting the coping of the wall. The concrete, which was laid wet, was in the proportions of 1 : 3 : 5, and the stone was crushed to pass a ¾-in. ring. The face was covered with a 2-in. layer of 1 : 3 mortar, applied at the same time the wall was built. A metal shield 8 in. deep and 6 ft. long was fitted with lugs which kept it the proper distance from the forms, and the space filled with the mortar. The shield was raised as the work progressed. A vertical expansion joint consisting of a V-shaped groove 1 in. wide was cut in the face of the wall every 30 ft., and has proved effective, as no cracks have resulted. During construction the walls were protected from danger of caving earth by timber sheeting. In one place on Grand Ave. the edge of the excavation is only 8 ft. from the foundations of the 4-story Atwater Block, and to avoid disturbance of the foundations steel sheeting was used. It is made up of Z-bars and channels from 33 to 34 ft. long, weighs about one ton per strip, and was driven with the aid of a jet.

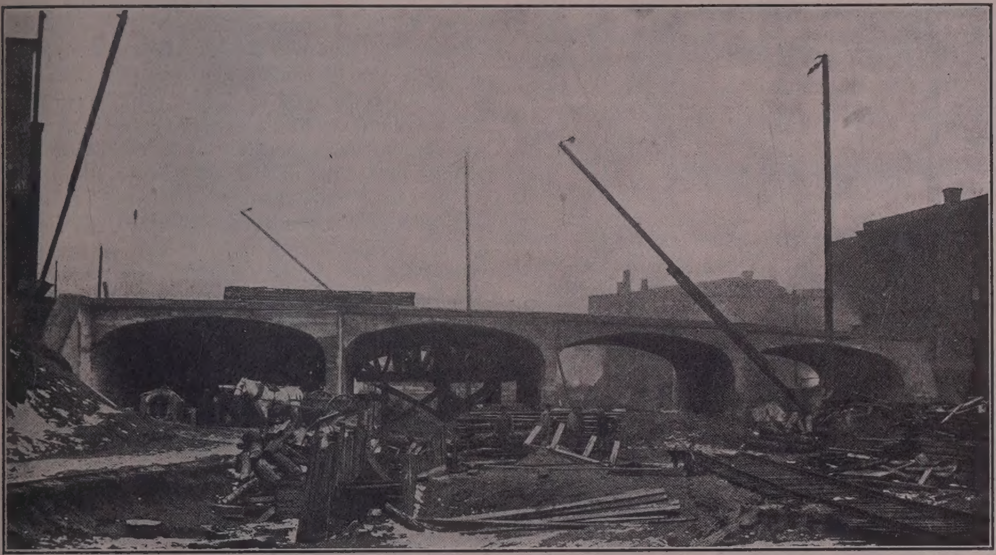
The cut is spanned by 6 plate girder, 1 truss and 6 reinforced concrete bridges. The clear headroom, 18 ft., is secured by depressing the tracks as above described, by using the smallest depth of bridge possible, and approach grades as high as 4 per cent. The plate girder bridges have spans varying from 63 to 75 ft. and vary in width from 26 to 45 ft. The girders are placed between the roadway and the sidewalks, the latter being carried on cantilever arms. The Olive St. truss is at an angle of 31 deg. to the track alignments and its abutments are concentric to the adjacent tracks, which are not parallel. As a consequence of these circumstances the trusses were not designed symmetrically and have few parts alike. Owing to the great number of train movements, it was thought advisable to make allowance in the design of the steel work for the destructive action of the locomotive gases, and therefore the largest size shapes were used in order to reduce the exposed surface, and the rivet spacing was made small so as to produce gas-tight joints. These considerations had weight; too, in the adoption of the reinforced concrete arches, whose smooth intrados allows of easy egress of smoke.

The reinforced concrete bridges are among the most interesting parts of the improvements. They are made up of series of three-centered arches, each of which reaches over two tracks and has a span of 31 ft. The Fair St. bridge, one of the longest, is composed of four arches. The foundations for piers and abutments rest on piles spaced with 3-ft. centers. The distinguishing feature of the reinforcement is the 60-lb. old rail in both the extrados and the intrados, and the use of railroad scrap, such as fish plates, old bolts, etc., wherever possible. Each arch unit consists of two rails, one curved parallel to the intrados, the other parallel to the extrados. They are connected by lacing made of plates ½ in. thick and 4 in. wide fastened with bolts. These rail arches are placed 3 ft. apart, though in a few cases both a less and a greater distance have been used, and between them are ½-in. twisted rods 1 ft. apart longitudinally and 2 ft. transversely. The rods are tied to each other and to the rails by ¼-in. iron wire. The entire framework is very rigid and not apt to be misplaced when the concrete is deposited; in fact, its strength is sufficient to support the arch lagging if it should be found necessary to erect a span without the usual falsework centering. The distance from the rail to the surface of the concrete varies from 3 to 6 in., no especial effort being made to bend the rails to the exact curves adopted. The crown thickness is 14 in. The wearing surface of the roadway will be a 3-in. coating of bitulithic paving. All the gas and water mains and telephone conduits are carried across the bridges imbedded in the sidewalks.

The sequence used in construction was to carry up the abutments and piers to the springing line across half the width of the bridge, and then place the concrete in ring sections, carrying each one entirely across to the next pier before starting with the next section. Owing to the necessity of maintaining traffic across the cut a temporary bridge is provided on one-half the street while the arch is being built in the other half. When the partially finished structure is opened to traffic the temporary bridge is removed, and the concrete bridge completed. On account of the interference of the forms the north arch of each bridge will not be built till the railroad traffic has been diverted to the new alignment.

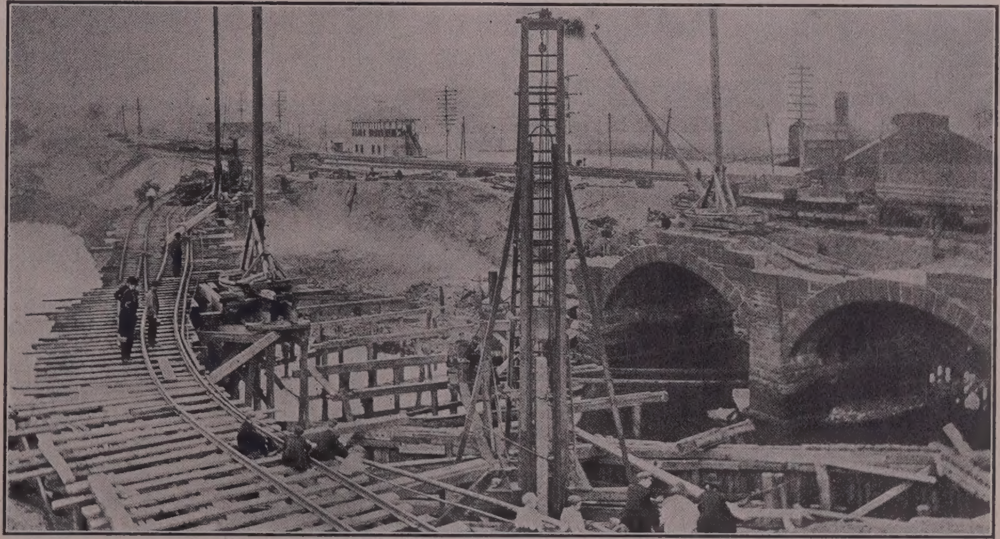
A 1 : 3 : 5 mixture is used in the concrete of the abutments and piers and 1 : 2 : 4 in the arches.

All concrete is placed wet. A good surface was obtained by spading against the forms and where surfaces were inaccessible, by placing a layer of cement mortar against the forms before depositing the concrete. As a final finishing the surfaces were scrubbed with sand and water as soon as the forms were removed. Excellent materials for concrete were obtained conveniently. The sand taken from the excavations along the work was of fine quality without clay or loam, and the stone was obtained from the contractor's quarries three miles from the city. A very hard trap rock was used, and was crushed to pass a ¾-in. ring. One yard mixers were used exclusively. The laying of concrete has continued throughout the winter, the materials being heated in severely cold weather. The forms are removed from retaining walls within 48 hours after the last concrete is placed, and the centering from the arches in a week and a half, these periods being lengthened according to weather conditions.



Fair Street Reinforced Concrete Bridge.

The railroad improvements are to be accompanied by increased facilities for the local street car system, which belongs to the New Haven Railroad. After the old tracks west of Chapel St. are removed, a 1,400-ft. viaduct, consisting of 30-ft. reinforced concrete arches, will be built in their place and the electric car tracks in State St. transferred to it. The object is to better the running time of the cars and the traffic conditions in the street. The new structure will be built along the rear line of the wholesale houses on the south side of State St., and the arch openings will allow access to side tracks.



Contractor's Plant and Old Bridge, Mill River.

The Fair St. bridge, which is at an acute angle with the center line of improvements, is built with the reinforcement normal to that center line, and as a consequence there are pier projections outside the street line on both sides of the bridge. All the other bridges, however, are being built with the reinforcement parallel to the street line so as to avoid these projections.

In two places cross streets intersect the main streets which bridge the cut, inside the right of way, the junction of the street lines in both cases coming near the crown of the south arch. The angle between the streets in neither case is a right angle. The cross street is carried over the south tracks on a cantilever, reinforced by brackets which have the same section as a corresponding portion of the arch, the very same centers and forms being used in both cases. In the first instance the crowns of the centers were all placed at the same elevation and the vertical section of the arch cut by the line of the cross street, gradually increases in depth from the thickness of the arch at the crown to the total height from the springing line to the extrados. In the second instance a more pleasing architectural effect has been sought, by making the vertical section cut by the line of the cross street of the same thickness throughout as the section cut at the crown of the arch where the two street lines intersect. This was accomplished by raising the centers gradually so that the springing line which was horizontal in the first instance gradually rises in a straight line, until its distance from the extrados equals the thickness of the vertical section cut at the junction of the street lines. The result is that the end of the brackets have the same depth throughout.

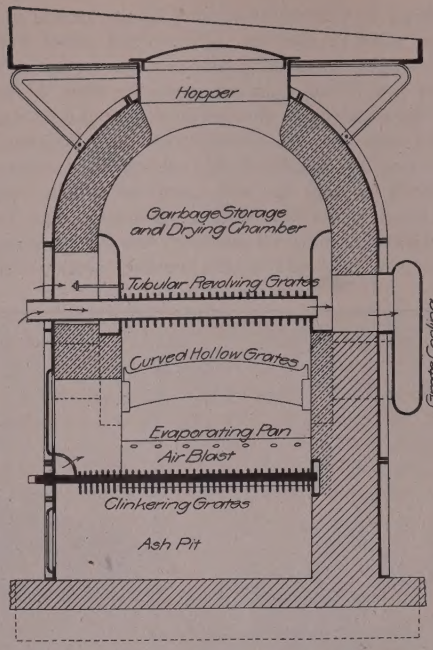
One of the most important parts of the improvement is the substitution of a 6-track reinforced concrete bridge over Mill River for the old 2-track masonry structure. After a temporary trestle for carrying the traffic was built south of the latter, the keystones of the arches were blown out with dynamite. Such was the strength of the mortar that many of the partial rings remained standing as cantilevers after the keystones were removed, and had to be wrecked with the aid of dynamite. A narrow-gauge track for handling material is supported on a trestle crossing the river to the north of the site of the new bridge. The latter will consist of reinforced concrete, two arches of 50-ft. span each. The general plan of the reinforcement will be that used in the street bridges, but Kahn bars will be used in place of twisted rods. Cofferdams of 6-in. Wakefield or tongue and grooved sheet piling were built around the sites of the abutments and the center pier. The sand was then dredged out of these to depths of 33, 18 and 16 ft. in the east and west abutments, and the center pier respectively. Piles measuring 35 to 40 ft. long were then driven and on them was started the concrete foundations. The bottoms of the latter cover the entire area of the cofferdams and the concrete is deposited under water until the weight is sufficient to balance the head of water outside when the cofferdam is pumped out. When the enclosure is emptied the forms for the upper parts of the abutments and piers are put in place. One-yard mixers are used and four derricks handle the material by means of bottom-dump buckets. The efficiency of the plant is shown by the depositing of an average of 130 to 150 cu. yd. per day per mixer. The total amount of concrete on the whole work, in bridges and retaining walls, is 80,000 cu. yd., of which 20,000 cu. yd. is reinforced.

The work is under the direction of Mr. E. H. McHenry, vice-president of the New Haven system, in charge of engineering, and Mr. M. C. Hamilton is in immediate charge. Messrs. C. W. Blakeslee & Sons, New Haven, are the contractors for all the concrete work and the Berlin Construction Co., Berlin, Conn., and Milliken Bros., Inc., New York, have the steel work.

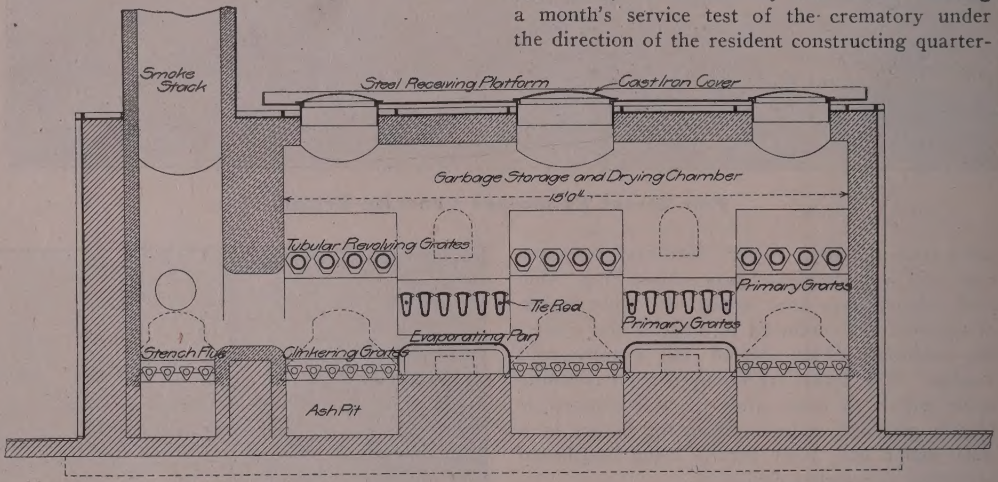
The Cost of Fireproof Office Buildings in New York, Chicago, Boston, Baltimore and St. Louis, from 9 to 14 stories high, has recently been investigated by Mr. F. J. T. Stewart, the results being published by the National Fireproofing Association. His figures show that the average cost of the foundation and mason work in such buildings has been 33 per cent. of the total, the steel frames have cost 17 per cent., the mechanical equipment and furniture 21 per cent., the trim and finish 27 per cent., and general expenses have averaged 2 per cent. The structures covered by these figures are all of the standard fireproof type conforming with the specifications of the National Board of Fire Underwriters, and do not include so-called fireproof buildings where the steel work is but partially protected or which are deficient in other essential features respecting fire protection. The experience gathered in the fires at Baltimore and San Francisco shows that buildings of this type, exposed to a conflagration, may be expected to sustain very heavy damage on all items of construction except foundations and steel frames. These two items represent approximately 20 per cent. of the value, and to them may be added about 10 per cent. for other salvage, chiefly on mason work, thus giving 70 per cent. damage.

An 18-Ton Garbage Crematory.

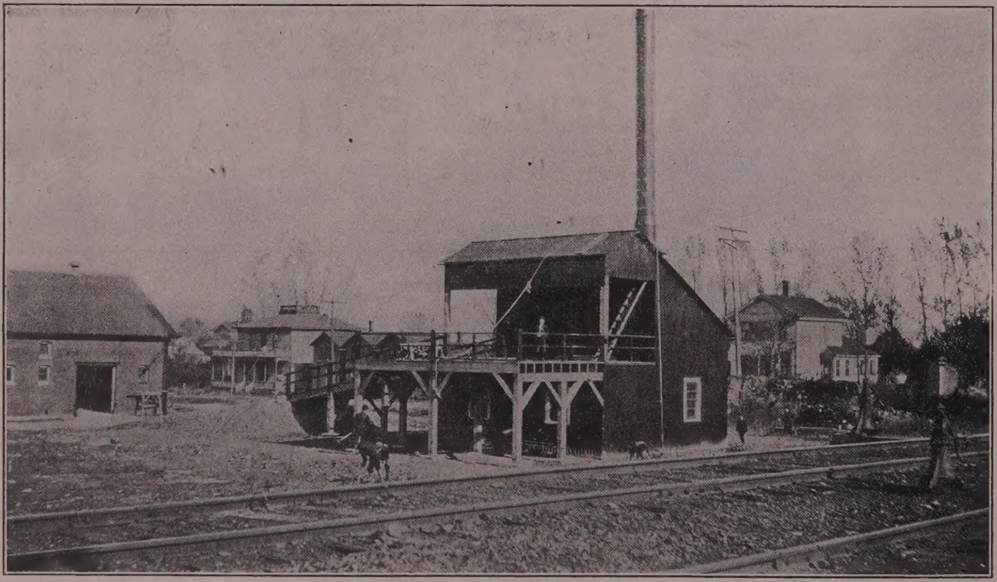
A garbage crematory designed to destroy 18 tons in 24 hrs. of the house wastes from 1,000 people, has been giving satisfactory service for several months at the United States Army post at Post Ontario, N. Y. This crematory is in a timber-frame building, 25 x 26 ft. in plan, which has a roof and sides of corrugated sheet-iron. The garbage is collected from the houses of the post in carts in which it is delivered to the crematory, a short run-way at the latter leading up to a dumping platform elevated 11 ft. above the ground and extending back into the building. At the rear of this platform is a receiving platform, or pan built of ¼-in. steel. This pan is carried on brackets on the cast-iron shell in which the cremating furnaces are enclosed. This shell is 8.75 ft. high, 21.5 ft. long and 5.75 ft. wide, and stands on a concrete base flush with the floor. Three 24 x 30-in. oval hoppers spaced equally in the top of the shell provide openings through which the garbage is fed into the furnaces from the receiving pan.



Section through Revolving Grates.



Longitudinal Section of Crematory at Port Ontario, N. Y.



The Garbage Crematory at Port Ontario, N. Y.

The general arrangement of the furnaces in the interior of the shell is shown in the accompanying illustration. The hoppers in the top of the shell open into a storage and drying chamber, the garbage falling directly from each of them on a set of horizontal tubular revolving toothed grates made of cast-iron. One end of each of these grates is open to the outside and the other end is connected with an air duct extending along the side of the shell of the furnaces to a connection with the 90-ft. stack which serves the furnaces. The grates are effectually cooled by the current of air thus induced to pass through them. Staggered between the revolvable hollow tubular grates immediately under the hopper openings are a second set of hollow cast-iron grates which are at a lower level than the first set. These lower grates are slightly arched across the furnaces and are also air-cooled in the same manner as are the upper sets of grates. Directly under the revolvable tubular grates and at a still lower level than the arched gates are revolvable clinkering grates. Between these clinkering grates and immediately under each set of the arched upper grates is an evaporating pan consisting of a flanged cast-iron plate, as shown in the illustration, on top of the brick work of the setting. The space under this plate is connected with the outside air, which is heated before reaching the combustion chamber.

The garbage on being discharged into the furnace nearly all lodges on the revolving tubular grates immediately under the openings in the top of the shell. As it is usually quite wet, not much combustion takes place on these grates except around the edges of the latter, the garbage being dried and partly coked on them. As the mass burns at the edges it breaks off and falls on the arched tubular grates at the lower level. The balance of it falls through the upper grates on the clinkering grates below where it is consumed, a small amount of coal being required on these clinkering grates only at such times as the garbage is particularly wet or is frozen. The air spaces under the evaporating pans are connected with the interior of furnaces at several points along the sides next to the clinkering grates so that a current of heated air may be supplied over the latter and in this manner a sufficient quantity of oxygen furnished to the fires on the upper or drying grates to support combustion on them.

The settings of the furnaces are connected at one end with a fire box directly under the stack. This fire box contains revolving grates on which a fire may be maintained to destroy any foul odors that may come over from the cremating furnaces. Thus far in the operation of the plant, however, the cremation has been so complete that no necessity for a fire at this point has arisen. In fact, the crematory has been operated entirely without offense, although it is in the immediate vicinity of a large number of residences.

The garbage that has to be destroyed is such kitchen and household wastes as are commonly produced in a northern community of the size served by the crematory. The latter operates almost without fuel, as fresh garbage is dried and burned with the charges of garbage which have been previously added and have had an opportunity to become dry and coked. During a month's service test of the crematory under the direction of the resident constructing quartermaster, Lieut. Henry H. Hall, only about $10 worth of coal was consumed. The garbage was collected daily to the amount of about 3 tons, and was deposited in the crematory which was operated 8 to 10 hrs. twice a week during this trial period.

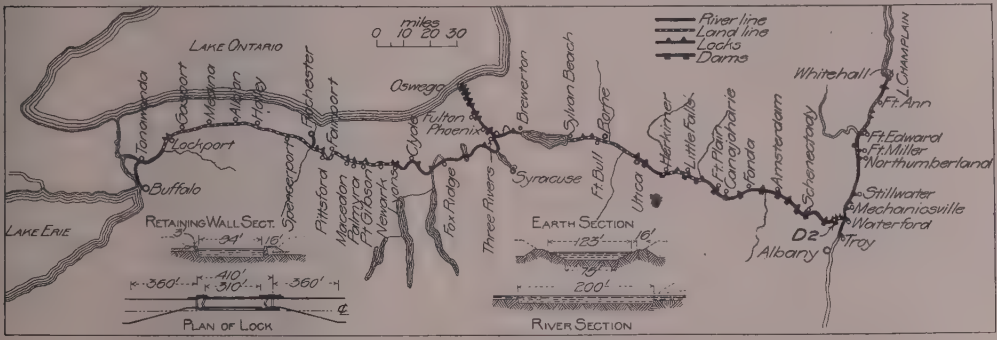
The crematory was designed and built by Messrs. Lewis & Kitchen, engineers and contractors, of Chicago and Kansas City, under the patents of Mr. Fred P. Smith, consulting engineer for that company.

The State Sewerage Commission of New Jersey has been laboring for some time under the disadvantages which always attend the work of a public body ordered to do certain things and not given sufficient authority to enforce its directions and to cover its field completely. The Governor of New Jersey recently called attention to the lack of authority on some subjects which this commission had, and as a result of his message a bill has been introduced in the State Senate which makes a number of important changes in the act governing the commission. One of these provides for action on the part of the commission against the pollution of water, without waiting for a formal complaint. Another change authorizes proceedings in Chancery to compel obedience to its orders where they meet with the approval of the court. Still another change defines the "waters of this State" so as to place the sewerage systems along the seashore under the jurisdiction of the commission.

The New York Barge Canal Improvements.

By Wm. B. Landreth, Special Resident Engineer.

Since the time that Albany was the frontier trading point of New York State and the outpost of the then civilization, the rivers of the central part of New York State have furnished the means of transportation of men and supplies. The Indians and trappers living along the Mohawk River and the lakes known as the "Finger Lakes," in bringing skins, hides and other merchandise to Albany for barter, followed the Mohawk River, Oneida Lake, Oneida River and Seneca River and its branches. As it became necessary to use larger boats for transportation, portions of the Mohawk River were improved, and early in the nineteenth century the first Erie Canal was built, with a depth of 4 ft. of water. This followed the Mohawk River to near Rome, then across the divide into Wood Creek, down that stream into and across Oneida Lake, down the Oneida River and up the Seneca River and its branches; then across country to the Tonawanda Creek and thus to the Niagara River at Tonawanda. When the canal was improved and deepened between 1840 and the early seventies, the route of the first canal was changed in many particulars by leaving the valleys of the streams and keeping along the side hills, and that canal was what may be termed a "high-line" canal; that is, while it followed in many cases the valleys it was constructed along the sides of the valleys rather than in the bed of the stream. In the plans for the barge canal which is now being built, the engineers have returned to the route followed by the Indians, trappers and early settlers of the State and by the first Erie Canal.



Map and Sections of New York Barge Canal Improvements.

A study of various routes for the barge canal, made in 1900, showed that a canal following the beds of the streams was cheaper than one along the sides of the valleys, and also that, owing to the wider channel in the rivers, boats could navigate then more rapidly than in a narrower channel on the high level. Another advantage was that by being in the stream, no water was lost from the canal by leakage through the banks, and that therefore, the canal could be operated with a smaller amount of water if built in the streams than if built on the higher level. An incidental advantage gained by following the beds of the streams is that the drainage of the country is greatly benefited and many swamps will be rendered tillable at no additional expense.

The line of the barge canal, with the location of the locks and dams and various cross-sections of the proposed canal, is shown on the accompanying map. Starting at the Hudson River at Waterford, the canal rises by five locks with a lift of 34 ft. each, to Dam 2 near Crescent, shown on the map by D2. The canalization of the Mohawk River from Crescent to Little Falls is secured by the building of dams at Vischer's Ferry, Schenectady, Hoffmans Ferry, Cranes Village, Amsterdam, Tribes Hill, Yosts, Canajoharie, Fort Plain and Mindenville. These dams form a series of lakes in the river and boats are passed from one lake to the adjoining one by means of locks. The lifts of the locks vary from 12 ft. to the extreme lift of 40 ft. at Little Falls.

Leaving Little Falls the river is followed to near Jacksonburg where it is necessary to leave it until opposite the village of Herkimer. A dam at Herkimer forms a lake in the Mohawk River extending to the eastern edge of the city of Utica. A dam at this point forms a pool in the river extending to the western limits of the city of Utica. A lock near the Rome, Watertown & Ogdensburg R. R. at the western edge of Utica, forms the eastern end of what is known as the Rome summit level, which has an elevation of 415 ft. above tide water at New York.

After passing through the summit level to a point near Fort Bull, west of Rome, the canal descends into Wood Creek and Fish Creek by two locks and enters Oneida Lake. Passing westward through the lake and into the Oneida River, the canal descends to the Seneca River at Three River Point. At Three River Point the main canal divides into two branches.

One is known as the Oswego Canal and passes by eight locks down the Oswego River to Lake Ontario, which it reaches at an elevation of 244.4 ft. above sea level.

The other, the main branch of the canal, passes westward up the Seneca River, the Clyde River and their branches to Macedon, and thence across various streams to the Genesee River at Rochester. From Rochester the canal follows practically the route of the present canal to Tonawanda, where it enters the Niagara River. From Tonawanda to Buffalo the Niagara River is to be improved by the United States Government, thus forming the connection from the Barge Canal at Tonawanda to deep water in Lake Erie.

Passing eastward from the Niagara River, the canal descends by successive steps from an elevation of 565 ft. at Tonawanda to an elevation of 363 ft. at the junction of the Seneca and Oneida rivers at Three River Point. It is thus feasible to feed the entire canal from Lake Erie eastward to the Oswego River by water from Lake Erie. The Rome summit level is to be fed from various sources. A portion of the water will be secured from the present Erie Canal feeders lying to the south of the present canal between Rome and Syracuse. A high dam will be placed across the Mohawk River at Delta, 6 miles north of Rome, forming a reservoir about 6 miles long and from one-half to one mile wide, from which water will be fed into the Mohawk River, and thus to the summit level at Rome. As these two sources will not furnish sufficient water, it is intended to build a reservoir on the West Canada Creek at Hinckley and carry the water from this reservoir through a conduit for about 5 miles, where it will enter Nine Mile Creek and pass down that creek to the summit level, about 6 miles east of Rome. In this way the water is secured for the portion of the canal between Rome and Oneida Lake, and for the portion between Rome and Utica.

The Oswego River will furnish ample water for the supply of the Oswego Canal between Three River Point and Lake Ontario. The summit level of the Champlain Canal lying between Fort Edward and Fort Ann will be fed from the existing Glens Falls feeder, which takes water from the Hudson River a short distance above Glens Falls. This feeder is of sufficient size to furnish the amount of water required for the Champlain Canal north and south of the summit level.

As the line of the canal between Rome and Cohoes, with a few slight exceptions, follows the bed of the Mohawk River, the subject of provisions for protecting the canal and its structures against damage from floods in that river is an important one. This question has received long and careful study by members of the State Engineer's force, and the result has been that a form of dam has been designed which permits the removal of the dam from the river in time of floods or when the canal is not navigated. (See Eng. Record, Feb. 2, 1907.)

The form of dam adopted is what is known as a "movable bridge dam." A heavy bridge is built across the river at the proposed location of the dam with spans of from 150 to 175 ft. in length. In the bed of the river under this bridge a concrete sill is built extending across the river. When it is desired to begin navigation in the spring heavy steel beams are let down from the bridge, the upper end being hinged to the bridge floor and the lower end resting against the upper edge of the concrete sill. Between the adjacent beams a series of steel shutters are placed thus forming a dam across the river. In times of low water in the river nearly all of the shutters will be in place, enough remaining open to maintain the water at the proper level for navigation. In the event of a sudden rise in the river, sufficient shutters are raised to allow the surplus water to pass, and in cases of heavy floods all of the shutters and their supporting beams will be raised and the river passes under the bridge unobstructed.

Dams of this type are placed at all the lock locations west of Schenectady. The two dams east of Schenectady, being in a narrow rocky gorge, are to be built of solid masonry for the entire height. The type of movable dam adopted for the barge canal work is not an experiment; several structures of the same type are now in successful use on various European streams. The experience gained by foreign engineers in the construction and manipulation of the type of dam shows that it is undoubtedly the best type for a river similar to the Mohawk.

On the Oswego River but two new dams are to be built and one of these takes the place of an old State dam which must be reconstructed. At other points on the Oswego River the existing State dams are used.

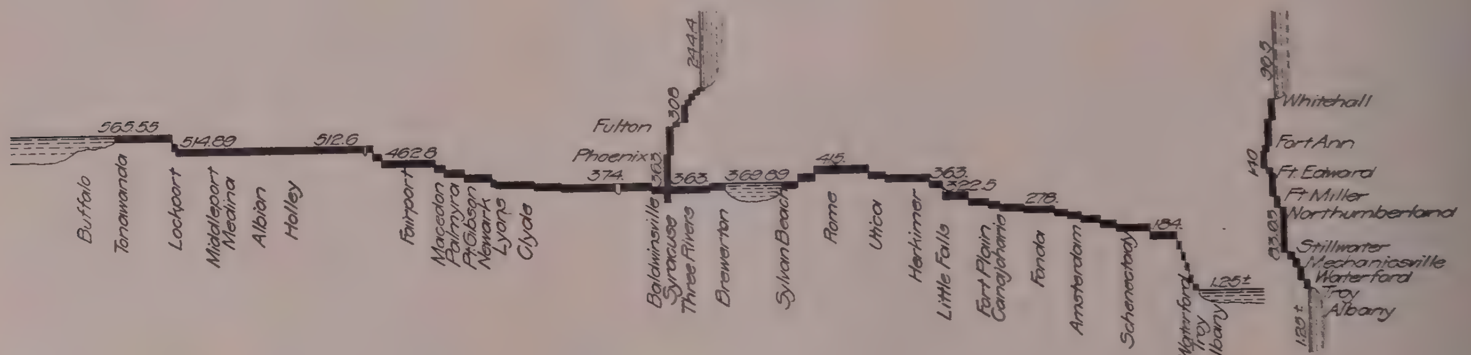
The barge canal route of the Champlain Canal follows the Hudson River from Troy to Fort Edward with the exception of about 3 miles of land line at Fort Miller. The Hudson River is canalized by the reconstruction of the existing State dam at Troy, the construction of a new dam about 6 miles north of Waterford and one at Fort Miller, and by the use of existing power dams in the river. As in the Mohawk River, locks are placed opposite the several existing or proposed dams.

From Fort Edward northward the canal will follow the lowest ground until it enters the valley of Wood Creek near Fort Ann, from which point northward it will follow in the bed of Wood Creek. A movable dam will be built at Whitehall and a fixed dam at Comstocks about midway between Fort Ann and Whitehall. At Whitehall the boats will enter Lake Champlain as at present, and by that lake and the Canadian Richelieu canal reach the St. Lawrence river.

Wherever the canal follows the rivers, as outlined above, the channel to be provided will be from 100 to 200 ft. in width on the bottom. In the land section a bottom width of 75 ft. will be secured. Throughout all the canals a depth of at least 12 ft. of water will be secured. The locks will be built of concrete; and the steel gates operated by electrical machinery. The lock chambers will be 310 ft. in the clear, 45 ft. wide and will have a depth of 12 ft. of water over the miter sills. The new locks will allow six of the present Erie canal boats to pass at one lockage.

The total length of the canals to be improved is 442 miles, or in round numbers, the distance between New York and Buffalo. The section from Troy to Buffalo is 353.5 miles long, that from Waterford to Whitehall, 57 miles; Three Rivers to Oswego, 22.6 miles; the Syracuse harbor line extension, 6 miles; the Rochester harbor line extension, 3 miles.

On the Champlain canal, all of the work between Northumberland and Whitehall, a distance of about 40 miles, is under contract. On the Erie canal the work between the Mohawk river at Waterford and the proposed dam near Crescent is under contract. The locks and dams at Schenectady, Rotterdam, Cranes Village, Amsterdam, Tribes Hill and Mindenville are under contract.



Profiles of Barge Canals under Construction in New York State.

On the middle section of the canal, contracts have been let for about 5 miles of the canal at the east end of Oneida lake and for 6 miles in the vicinity of the Montezuma marshes. On the western section of the canal contracts have been let for 3½ miles for a rock cut 35 ft. deep near Rochester and for the canalization of the Tonawanda creek for 12½ miles east of Tonawanda.

On the Oswego canal a contract has been let for locks and dams in the city of Fulton, and contracts have also been let for bridges at various points.

The total of the contractors' bids for all of the work now in progress is $15,275,548. The cost of engineering, right-of-way and other work within the limits of the contracts already let, in addition thereto, will amount to $4,250,000.

Final surveys have been completed for all of the caanls with the exception of a portion of the Hudson river and for a line between Savannah and Pittsford near Rochester.

In addition to the work under contract, plans have been practically completed for work estimated to cost $15,400,000. By the end of this year all of the work between Waterford and Lake Ontario, estimated to cost about $40,000,000, should be under contract as well as that for a considerable portion of the other lines of the canal.

[The organization of the engineering staff in charge of the canal work was described in the Current News Supplement of The Engineering Record of Jan. 5, 1907. It is under the general direction of Mr. Frederick Skene, state engineer, and Mr. William R. Hill, special deputy state engineer, in direct charge of the barge canal improvements.]

The Khushalgarh Cantilever Railway Bridge across the Indus.

The Kohat Branch of the Northwestern Ry., of India, crosses the River Indus at Khushalgarh with a two-span bridge 774 ft. long between the massive abutments. The riveted trusses, 45 ft. deep and 20 ft. apart on centers, carry the track on the upper deck at the top chord level and the highway on a solid longitudinal trough floor at the lower chord level. The trusses of the 303-ft. spans are continuous across the top of the pier, forming a cantilever arm 104 ft. 8 in. long, corresponding to an equal cantilever on the opposite side of the channel, from both of which the 261 ft. 8 in. center span is suspended. The west cantilever arm terminates at the abutment, where its top chord is anchored by a chain made of three panels of eye bars 30 ft. long inclined about 30° to the horizontal and terminating in a panel of diverging eyebars, with the pins through their lower ends engaging half holes in a casting with longitudinal and transverse stiffening webs 4 ft. deep and a 6½x10-ft. base normal to the direction of the anchorage chain, which is built solidly into the mass of the concrete abutment. Horizontal reactions for the wind stresses in the top chord systems are provided by vertical bearing plates on the abutment towers, which engage the edges of the top chords and allow the latter to move freely in a longitudinal direction.

The center span is suspended from the ends of the cantilever arms by sets of vertical eyebars engaging pins through the projecting gusset plates in the top and bottom chords. Temperature movements due to a change of over 100° are provided for, but are concentrated to operate only at one end of the suspended span, the construction at the other end being locked subsequent to erection.

Erection adjustments are provided at both ends of the suspended span, where cast-iron wedges operated by worm gears engage cast-steel bearing blocks and permit an adjustment of 3 in. at each wedge. In order to allow for considerable variations of length in the members of the bridge due to a change in temperature at the time of erection, one face of each wedge is vertical and provided with a set of steel shim plates, which can be adjusted to make it thick or thin.

A peculiar feature for the design is the bearing for the 303-ft. anchor span on the center pier, where it was thought that ordinary supports would tend to cause a splitting stress in the pier masonry on account of unequal horizontal wind deflections in the two adjacent spans. The lower chord of each truss has bolted across its bottom flange a 40x52-ft. cast shoe with a concave bearing to fit the transverse cylindrical top surface of the pedestal. For the truss exposed to prevalent winds, the pedestal is seated on a disc 4 in. thick, which permits it to revolve about its vertical axis. The pedestal for the other truss cannot revolve, but it can slide back and forth a short distance on its bolster. The pedestals are 31 in. high with bases 5½ ft. in diameter, and the bolsters are about 2 ft. high with bases 9 ft. 9 in. in diameter. Oil cups and oil grooves are provided for the bearings between the shoe and pedestal and between the pedestal and bolster discs, and the latter are covered by an annular plate. The shoes are of cast steel and the pedestals and bolsters are of cast iron, the latter being made in four sections bolted together through their transverse and longitudinal vertical webs.

The entire superstructure was erected in the yard of the Teesside Bridge & Engineering Co., Ltd., the contractor, of Middlesbrough, England. The anchor spans, both cantilever arms and the suspended spans were assembled separately, together with all of both floor systems, and the pieces carefully fitted and match-marked for re-erection in India. The erection at the yard was accomplished by a wooden gantry traveler like those used for the ordinary erection of pin-connected trusses on falsework in America. It is interesting to note that the eyebars in the cantilever anchorage and for suspending the center span were made at the Ambridge Plant of the American Bridge Co. The bridge was designed by Messrs. Rendel & Robertson, and was described in a recent issue of "Engineering," of London.

The Cazadero Power Plant.

The Cazadero hydro-electric power station recently completed for the Portland Railway, Light & Power Co., is the largest electric plant in Oregon. It is 38 miles from Portland on the Clackamas River, and has a present capacity of 15,000 h.-p., which will be increased shortly to 25,000 h.-p. About a mile above the station is the dam, 176 ft. wide, 130 ft. long at the base, and 400 ft. long at the crest. The water is diverted from the river at this dam through a 17x25-ft. bulkhead into a flume 2,622 ft. long. This flume discharges into a canal 2,898 ft. long, 35 ft. wide at the bottom, 20 ft. deep and 75 ft. wide at the top. This canal empties in turn into the main reservoir, which covers 50 acres when filled to an average depth of 20 ft., and has a capacity of 328,500,000 gal. From the forebay at the lower end of the reservoir the water passes to the power house, 138 ft. below, through 8-ft. pipes inclined at an angle of 45 deg. down the hillside. The power house is a concrete building, 180 x 54 ft. in size, and contains three double 42-in. Allis-Chalmers turbine wheels direct-connected to three generators of the same make. The generators have a rated capacity of 2,500 kw. each at a terminal pressure of 11,000 volts. Each alternator is equipped with a direct-connected excitor on the end of its shaft. The current is taken across the river to a transformer house where the voltage is stepped up to 30,000 volts for transmission, and is stepped down again to 10,000 volts just outside the city of Portland. A duplicate of Cazadero station has already been begun a few miles farther up the river.

The Strauss Trunnion Bascule Bridge near Rahway, N. J.

The New Jersey Short Line Railroad, a double track interurban line now under construction between Philadelphia and New York, crosses the Rahway River at a point about four miles below Rahway, N. J.

The Rahway River being navigable, compelled the use of a movable bridge, and a 150-ft. double arm plate girder draw span was originally proposed for the crossing. This design was subsequently abandoned and the contract awarded to the Strauss Bascule and Concrete Bridge Co., on their bascule design.

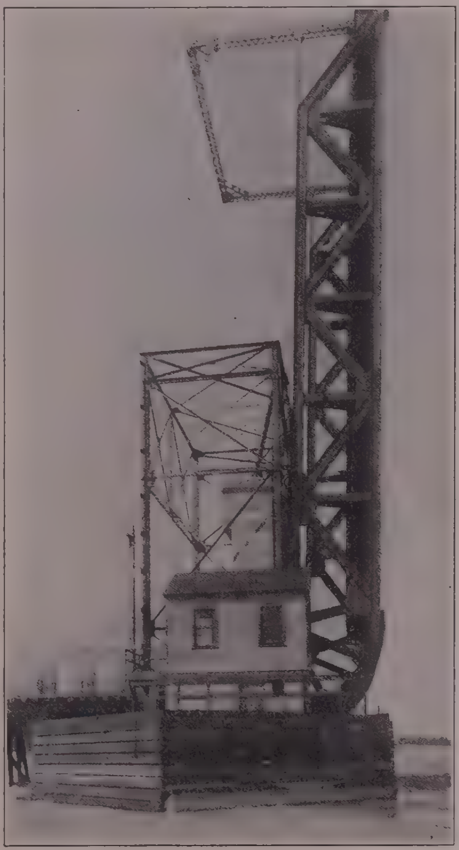
The bridge crosses the river at right angles, the clear span being 65 ft. and the distance from the center of the trunnion to the rest pier 83 ft. The length of the tail end or counterweight arm is 13 ft. The 17x33½-ft. tower is 50 ft. 3 in. high above top of masonry and 44 ft. 9 in. high from base of rails. The distance center to center of trusses is 30 ft.

The single moving leaf has two riveted pony trusses with box girder sections. The front part is a Warren truss and the tail end is polygonal. The trunnion is located at the junction point of the front part and tail end and is the center from which the truss members radiate, as well as the point to which the entire dead and half of the live load on the moving leaf is transmitted.

Simplicity, economy and safety are promoted by the arrangement and operation of the overhead counterweight which is an important and characteristic feature of the Strauss type of bascule. The main trusses are pivoted to horizontal trunnions passing through the shore end of the top chord and supported by a pair of vertical posts, one on each side of each truss. The bottom chords project on the shore side of the trunnions and are curved upward to intercept continuations of the top chords and form braced quadrants carrying on the lower surface a rack engaging the operating pinion on the top of the pier below the floor level in the vertical plane of the trunnion. To the outer extremities of the quadrants are pivoted the lower ends of the vertical frame containing the overhead counterweight, arranged so that they may be vertically and horizontally transposed as the bascules are opened or closed. This is effected by connecting the upper ends of the counterweight frame to the upper ends of vertical extensions of the outside bascule posts by struts pivoted at both ends. The counterweight frame, bascule posts, top struts and the main truss extensions between the trunnions and the counterweight pivots thus form four sides of a parallelogram pivoted at each angle.

The side formed by the extensions of the bascule posts is maintained in a fixed vertical, and as there are no diagonals the opposite sides of the parallelogram are free to move back and forth like the blades of a parallel ruler when the bascule leaf is revolved up or down. The counterweight thus always maintains a vertical position, and is supported wholly by the end of the quadrant extension of the main truss, and is guided and maintained in equilibrium only, by the struts attaching it to the bascule post. As it moves up or down, its horizontal distance from the trunnion varies and the length and weight are so proportioned that its variable moment corresponds always with that of the bascule arm due to its different positions as it rises and falls, and thus maintains it in perfect equilibrium at all times. The pivoted struts in the top of the counterweight frame are X-braced to give them rigidity and the tops of the bascule post extensions are braced longitudinally and transversely and, together with two rear vertical posts, form a tower enclosing the movable counterweight and having clearance through the lower part for the bridge traffic.

Among the advantages claimed for this type of construction are, first, the ability to increase or diminish the weight of the counterweight without at all changing the center of gravity, thus greatly promoting the ease and accuracy of adjustments. Second, perfect balance for the bascule leaf in all positions, thus making its motion always positive and reducing it entirely to overcoming the friction and inertia. Third, the reduction of friction, the pressure on the trunnion and counterweight pins being limited to 1,400 lb. per sq. in. Fourth, freedom from the possibility of accidentally opening the bascule under live loads which is secured by making the break in the floor in advance of the trunnion; consequently no tail locks are required, and the bridge is safe independently of its operator. Fifth, minimum clearance above water level and elimination of counterweight pits. Sixth, minimum over all length for required span.



Bascule Bridge Open.

The moving leaf comprised in addition to the two trusses all that part of the floor beyond the break in floor. This part of the trusses is held laterally by deep knee braces at each floor beam and by angle laterals. The tail ends are unsupported laterally beyond the trunnion, but the width of chord is exceptionally great in proportion to their unsupported length, and the tail ends are fully as stiff as the remainder of the trusses. Their function is to transmit the effect of the counterweight and carry the operating rack.

The trunnion supports are two cast steel journals riveted to a pair of short vertical posts, one on either side of each truss. Heavy knee braces hold the outside posts laterally, the inside trunnion posts are riveted to the front floor beam of the fixed approach, while the rear tower posts are riveted to the rear floor beam of the fixed approach. The longitudinal bracing of the inside trunnion post is by means of a batter post and a horizontal strut to the rear floor beam, acting in connection with the bottom lateral system of angle bracing. The fixed floor is supported on stringers spanning the space between the fixed floor beam and by brackets to the break in floor. This form of tower construction gives solidity and stiffness.

The counterweight frame has two horizontal plate girders 30 in. deep, 24 in. apart on centers and 30 ft. long, which are web-connected at their ends to vertical posts 32½ ft. long at points above traffic clearance and about 10½ ft. in the clear above the centers of the pinions to which they are pivoted. The upper ends of these posts are connected by a transverse strut and the panel between it and the plate girders is X-braced by diagonals. Just above the transverse struts each post is connected to the top of the tower posts by a pair of pin-connected X-braced struts. At four nearly equidistant points the girder webs are connected by solid vertical transverse diaphragms extended on the opposite sides of both webs by solid-web brackets 3 ft. wide, with the top flanges of both brackets and diaphragms field riveted to full length 13x½-in. cover plates 8 ft. long, which afford transverse support to the lower part of the concrete counterweight. The concrete counterweight block 31 ft. 8 in. wide, 8 ft. thick and 32 ft. 9 in. high extends from the bottom flange of the plate girders to above the top of the vertical posts and from out to out of the vertical posts, thus entirely enclosing the steel work of the counterweight frame, and providing a total weight of 712,000 lb. of concrete, which is reinforced by 12 vertical and 22 horizontal bars, all of them ¾ in. in diameter.

The counterweight frame, as a member of a flexible parallelogram, can alter its relative position to the trunnion without changing from the vertical, thus maintaining an exact balance as the bridge opens and closes. The counterweight itself is high enough to permit such dimensions as are required for the use of concrete instead of the expensive cast iron; its point of application, however, is low and the center of gravity remains in the center of the trunnion close to the base of the rails. In other words a high counterweight is obtained without a high center of gravity and the consequent low factor of stability.

The bascule is supported entirely from its trunnions and the sum of live and dead loads transmitted through the vertical posts to the abutment masonry amounts to 661,000 lbs. per truss, which is distributed over the concrete by a 4x9½-ft. grillage made of 9-in. I-beams with 20x⅞-in. top flange cover plate, and secured by eight 1¼-in. vertical anchor bolts 3½ ft. long.

The machinery is located on top of the pier and on either side of the tower. It comprises two separated trains of gears and two driving pinions, meshing with cast steel segmental racks fitted to the tail ends of the trusses of the moving leaf. The driving motors are of the direct-current railway type and together with the machinery are enclosed in wooden houses symmetrically located on opposite sides of the roadway with roofs flush with the base of rails. On one side this roof forms the floor of the operator's house, which contains the controller, switchboards and the hand levers for the brakes, truss and rail lock and the semaphores.

The track rails on the bascule are spliced to the fixed rails at both ends of the bridge with side plates raised and lowered with toggle joints and operated by a transverse shaft commanded by tension rods under the bridge floor. The truss lock is a longitudinally moving tongue, engaging a slot on the end shoes. No tail lock is provided, there being no live load on the tail end and, therefore, no tendency for the bridge to open under load. The two 15-h.-p. General Electric motors which operate the bascule are geared to reduce their speed about 120 times. A winch for hand operation is also contained in the operator's house as well as an indicator showing the position of the leaf and an air whistle in place of the old fashioned draw bridge bell. Walks and stairways are provided to all the machinery parts and the tower is fitted with a ladder on the rear post which gives access to the link pins.

The bridge is provided with end shoes designed to act as buffers and absorb the impact of the leaf as it descends. For the upward movement an automatic motor cut-out is provided as well as bumping blocks of white oak in the trunnion posts and a corresponding engaging shoe on the tail end. The equipment includes two one-arm semaphores; two automatic signal lights, showing red when the bridge is closed and green when it is open, and four fixed lights on the piers.

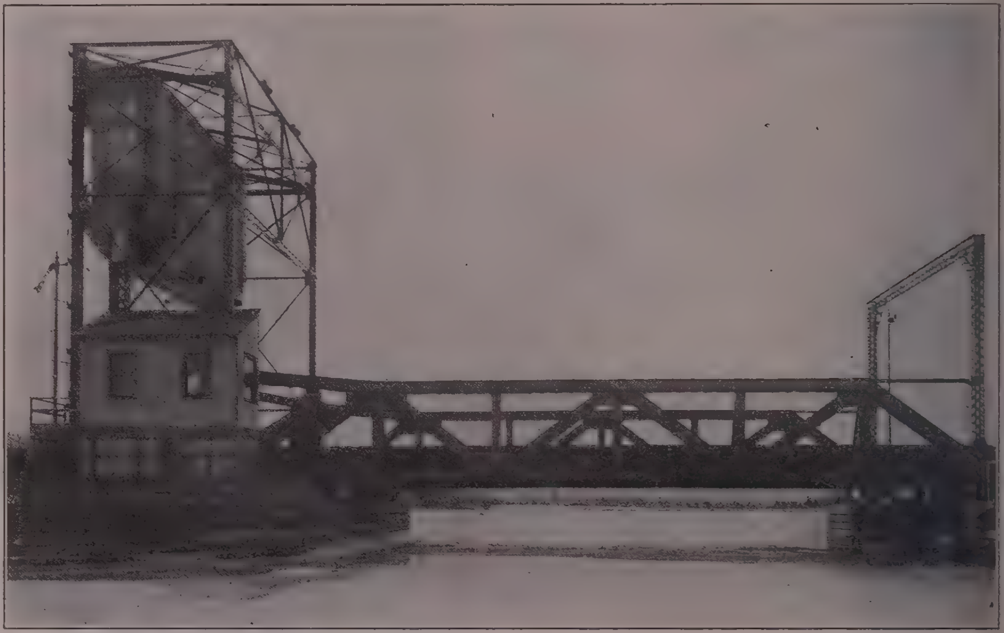
The contract requirement as to speed of operation calls for a leaf movement of one minute and a quarter of a minute for the operation of the locks. This is fully met. The motion is smooth and regular and the leaf being perfectly balanced there is no tendency to race. The power required is about 20 amperes at a voltage of 450. The hand operating mechanism raises the bridge in 30 minutes under the high speed gear and in 60 minutes under low speed, with one man at the winch. This mechanism is an emergency device and is ordinarily disconnected.

The road being an interurban line it was necessary to make provision for the trolley wires. At the end of the leaf, this was done by riveting a structural steel trolley arch to the end floor beam and bracing it back to the truss in the line of the top chord. At the tower end T-iron brackets were built into the counterweight for the attachment of insulated brass pans to guide the trolley. The trolley wire of the leaf passes over a sheave in the front pan and thence to a compensator on the front face of the counterweight, the device being such that the wire is always kept taut whether the bridge is open or closed. In the open position the trolley wires ride on iron rollers at the top of the tower; the wire being dead when the bridge opens there is no transmission of current to the bridge metal. The approach wires are supported on the end frame of the tower at one end and on a trolley arch on the fixed approach at the other end.

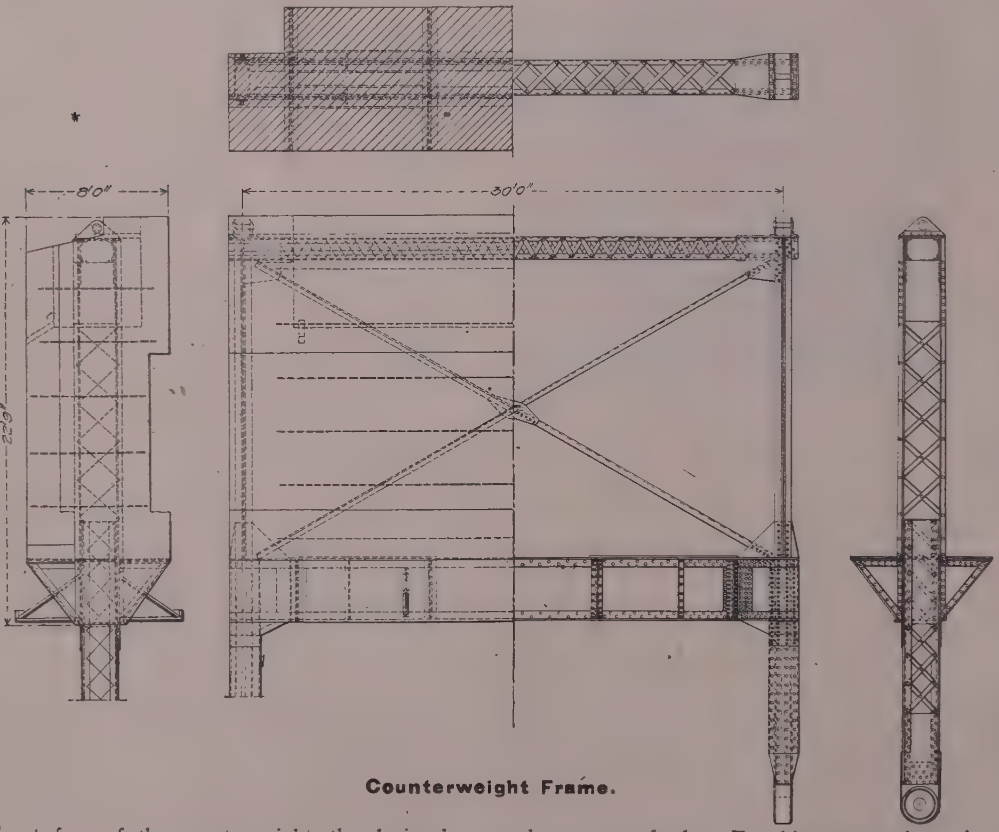
The bridge floor has 8x9-in.x22-ft. ties continuous over both tracks secured to the stringers by four ¾-in. bolts for each tie. The usual timber guard rails and also two lines of walking planks are furnished.

The substructure of the bridge embraces a concrete pivot pier and a pile rest pier. The former is U-shape to suit the tower and rests on short piles driven to a stratum of shale. Its construction was carried on by means of a puddled cofferdam, which was designed to remain in place and serve as a fender. For this purpose the puddle was removed after the pier was finished and replaced by broken stone. The rest pier is similarly protected by a fender.

In addition to the points already mentioned the noticeable features of the bridge are its straight line construction, and the economical use of concrete counterweight, the absence of curved structural parts and of special machinery parts. The only wear is on the phosphor bronze bushings of the trunnions and counterweight pins; the stress on the link is nominal only and introduces no appreciable friction. All the main pins have been provided with double lock keys which prevent their accidental dislodgement under any circumstances and which were successfully used on the Cleveland bridge to remedy this, the only trouble which developed in the practical operation of the bridge. The truss is very substantial and heavy, and its lines are well adapted to hard railway service.



Bascule Bridge Closed, with Counterweight Raised.



Counterweight Frame.

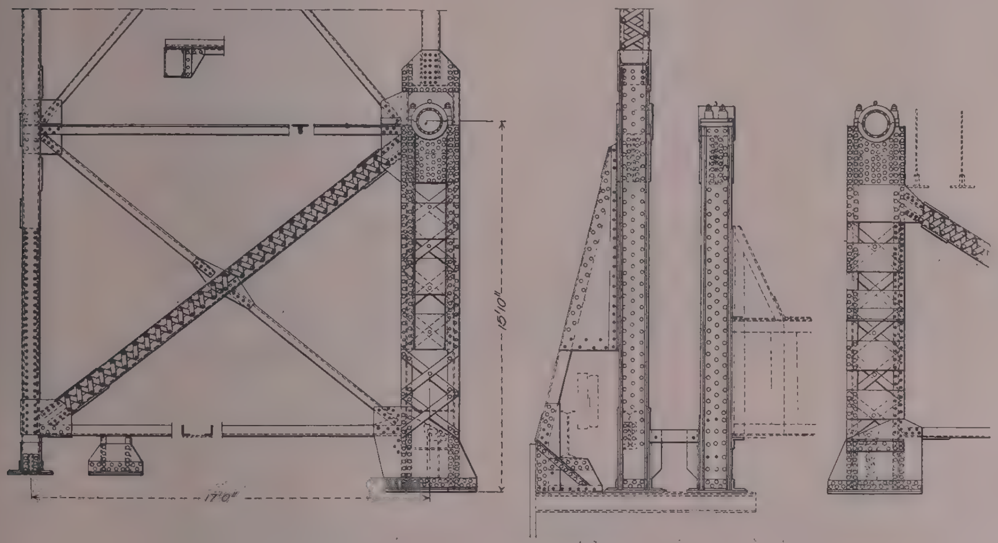
The contract for the substructure was awarded to F. M. Stillman Co., 26 Exchange Place, Jersey City, and work was commenced on it Oct. 1, 1905, and finished Feb. 1, 1906, five hundred barrels of Alpha Portland cement being used for it.

Ordinary trestle falsework was erected for the approach span and on it a cement house, contractor's office, tool room, etc., were built and a derrick with a 40-ft. boom operated by a 2-drum Mundy hoisting engine was installed, and with it the trunnion posts were first erected. The rear end panels of the trusses were then erected between the trunnion posts, the counterweight tower was erected and the curved portions of the trusses were completed and braced to it, after which the erection derrick was moved to the top of the tower and completed the erection of the bascule trusses in their vertical positions. The floor beams were permanently connected to the trusses and being thus temporarily placed with their webs horizontal, served as very convenient riveting platforms. A Clayton air compressor was installed and operated two Ingersoll-Rand pneumatic hammers with which about 8,000 ⅞-in. field rivets were driven.

Concrete materials were brought by lighters to Elizabethport and there unloaded at the wharf and brought to the bridge site every other day by scows which were moored alongside and provided platforms where the 1:2:4 concrete for the counterweight was hand mixed. It was made partly with Penn-Allen and partly with Alpha Portland cement and was hoisted in one yard cyclopean steel buckets by a tackle suspended from the top of the counterweight tower and operated by the hoisting engine. It was dumped on a movable horizontal working platform, and thence shoveled into the mold built up around the framework of the counterweight support. The back wall of the mold was at first built to the full height, but the front wall was built in steps as the concrete was filled in and the platform carried up to correspond. The counterweight was built after the erection of the steel work, but before the ties, rails, racks, trolley arch and some other portions of the structure were added and was therefore left incomplete until these were all in position, when the proper weight of concrete was added to create an exact balance. During construction the tower was temporarily braced by inclined shores on the land sides.

The steel work weighs about 391,000 lb. and its erection was commenced about the middle of September, 1906, and was sufficiently completed for the bascule leaf to be lowered to position November 25, 1906. The average erection force consisted of 12 bridge men, 1 mason and 3 carpenters, besides a machinist helper, 2 painters, 2 electricians, and from 10 to 12 laborers occasionally employed. The steel work was fabricated by the Toledo-Massillon Bridge Co., and was designed and erected by the Strauss Bridge Co. Mr. Harry Fowler, Toledo, was the contractor for the electrical appliances.

The Rahway River Bridge is the Second Strauss Trunnion Bascule Bridge to go into service, the first being the 150-ft. single leaf span for the Western and Lake Erie R. R., at Cleveland, Ohio, which has been in successful operation since October 23, 1905. In addition to these two bridges constructed there are six additional Strauss Bascules under construction, including the monumental Knippels Bridge at Copenhagen, Denmark, which was selected by international competition.



Lower Part of Counterweight Tower and Trunnion Posts.

The Water Purification Problem at Washington is not wholly solved by the present filters, and experiments have been started to ascertain, first, if preliminary filtration removing a part of the turbidity of the raw water will permit the main filters to furnish uniformly good water; second, the most effective system of preliminary filtration; third, the possible utility of a coagulant. Two preliminary and three main filters and a settling basin have been built for the experiments.

The Theory of the Design of Railway Freight Terminals.

Abstract of a paper read before the Western Society of Engineers by H. M. North, Assistant Engineer of Construction, L. S. & M. S. Ry., Cleveland, Ohio.

The general purpose of legitimate railway construction is to provide facilities for the forward movement of traffic. In a freight terminal yard, this means the facilities to receive incoming freight trains, rearrange the individual cars and their contents in proper order for going forward, and to deliver the cars so arranged to road crews or switching crews for the proper forward movement.

The movement through a terminal yard to accomplish this purpose is more or less similar for all classes of business, and advisable differences in the outline and dimensions of yards are for the purpose of expediting and economizing the operations to suit these varying classes of business; in nearly all cases, however, the yard arrangement desirable for effective operation is adversely affected by local conditions, such as the lay of the ground, the position of connecting railway lines, and permanent construction and allied considerations, to all of which the yard design must be adapted.

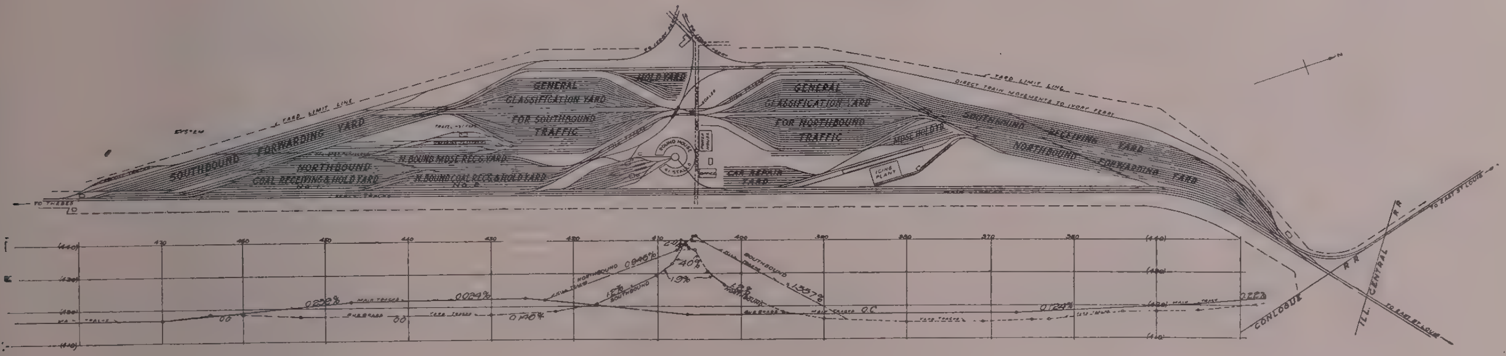

GENERAL CLASSIFICATION YARD FOR SOUTHBOUND TRAFFIC
HOLD YARD
GENERAL CLASSIFICATION YARD FOR NORTHBOUND TRAFFIC
SOUTHBOUND FORWARDING YARD
NORTHBOUND COAL RECEIVING & HOLD YARD No. 1
N. BOUND MDSE. REC'G. YARD
N. BOUND COAL REC'G. & HOLD YARD No. 2
ROUND HOUSE
CAR REPAIR YARD
ICING PLANT
MDSE. HOLD YD.
SOUTHBOUND RECEIVING YARD
NORTHBOUND FORWARDING YARD
YARD LIMIT LINE
DIRECT TRAIN MOVEMENTS TO IVORY FERRY
TO THEBES
TO EAST ST. LOUIS
ILL. CENTRAL R.R.
CONLOGUE
N

Fig. 1.—Missouri Pacific Yard at Dupo, Ill.

The time of ordinary freight through a terminal yard should not and need not exceed four hours, from the time of receipt until departure; expedited freight can readily be put through in one hour's time; and freight that must be transferred, rearranged, shifted or otherwise given extra handling, should not be detained to exceed twelve hours. These requirements as to time are not only essential for economy, but for the conditions of competition as well. The cost of moving freight through terminals can be held down to less than fifteen cents per car for all operating charges including breakage of cars. The actual cost per car on the same basis in the average yard probably approximates thirty cents. The difference between these two figures is the saving that efficient design of trackage, grades and facilities effects.

The bulk of work in a freight terminal yard is the separating or classifying of cars. This is accomplished by switch engine service in some one of several ways. The ordinary method of pushing and pulling, or as it is more commonly known, the "kicking" method, is the best known. It is adaptable to almost any lay of ground, costs the least in first construction and within the limits of effectiveness, when well handled, a yard so designed does excellent work. Only a limited number of cars can be handled by this method, and these at a higher cost of operation and higher cost for breakage of merchandise and excessive damage to equipment.

The "poling" method has been used as an improvement on the "kicking" method, to lessen the damage claims, and damage to cars, as well as to increase the capacity of the yards. It requires an extra track parallel with the ladder to which the body tracks of the yard connect, and requires these two tracks to be tangent or nearly so; its first cost is accordingly somewhat greater than that of a kicking yard, and it demands more favorable ground than the kicking yard. It will handle about 100 per cent. more traffic than a kicking yard, at a somewhat smaller expense per car, *if well handled.* This last clause must be clearly remembered, in judging of the success or failure of a given poling yard. The almost irresistible tendency is to attempt to handle poling yards with an insufficient force of switchmen, and the resulting breakage of cars and contents has reacted against this general method of switching.

The application of the power of gravity to give cars the forward movement to carry them into their respective classification tracks, has developed sufficiently so that it may be confidently stated that this method is the best and the only one, so far attempted, which will handle heavy business speedily, economically and satisfactorily.

There may be said to be four principal handlings of freight cars and one auxiliary handling of a portion of them, involved in the movement of all traffic through a freight terminal. These handlings are: 1. The receiving of incoming trains and the work incidental thereto. 2. The separating or classifying of cars, more commonly known as "breaking up" trains. 3. The grouping into train order for advance movement, of the separated or classified cars, commonly known as "making up" trains. 4. The forwarding of trains, and the work incidental thereto. The auxiliary work is the rearrangement, consolidation and transfer of freight for reasons of economy, safety, or because of the need of repairing the cars; the icing of perishable freight, or the feed, water and rest needed by stock.

The Receiving Yard.—For receiving the incoming trains, a so-called "receiving yard" is needed. This yard should have tracks of a sufficient length to admit the maximum length trains that can be anticipated, without doubling in. As there will be many short trains, these long tracks should be provided with a reasonable proportion of crossovers to thoroughfares so that a short train will not block the entire length of a track for a maximum length train. Also, as a number of trains have cars of perishable or live freight directly behind the engine, trackage outlet independent of the regular outlet of the receiving yard should be provided to afford a direct and immediate movement to the icing plant or stockyard, so the road engine can quickly take this high grade freight to these points.

The time of a train in a receiving yard under average conditions should not exceed one hour, for the purpose of cutting off the road engine and the caboose, the inspection of cars for defects, and the coupling on of the switch engine in readiness to commence breaking up the train. This hour of time can very wisely be used for making the light repairs to the cars needing such, and as a usual thing, about one-half of the defective cars in certain large yards are repaired during this period of inspection. This work can be done with the tracks on thirteen-foot centers, but where there is space available, fourteen-foot centers are preferable. The number of tracks in such a yard should be sufficient to hold the accumulation that may result from any likely derailment in the advance movement through the general yard system, or congestion from other causes.

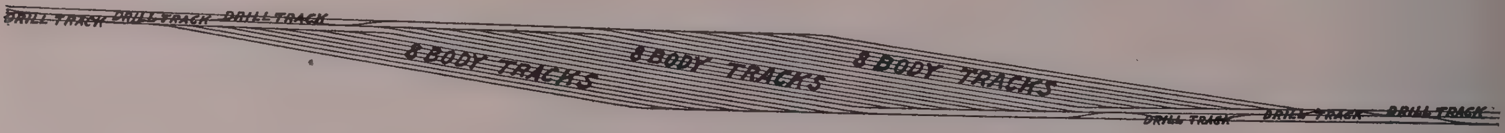


Fig. 2. Classification Yard, Three Units of Eight Tracks Each.

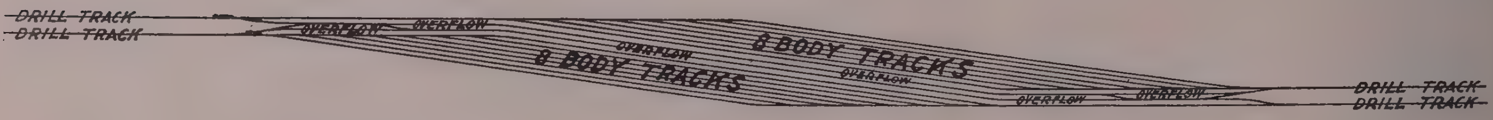


Fig. 3. Classification Yard, Two Ladder Units with Overflow Tracks.

An important and very necessary adjunct to a receiving yard, is the trackage for "hold" business. There are always cars without way bills, cars of unconsigned lumber and unconsigned coal, to be held for billing at any terminal; these cars should never be allowed to block a receiving yard. It is bad operating policy to classify an entire string of cars to secure an occasional car for which billing has come, or to dig out these occasional cars from the long strings of cars by the push and pull method. Accordingly, there should be placed alongside the receiving yard, a sufficient number of moderate length "hold" tracks, which should be under control by the most generous proportion of drill tracks of the entire yard system. The author makes it a practice for the usual coal hold yards to equip each four body tracks with an independent ladder drill track at each end.

The Separating or Classifying Yard.—When solid trains of through freight come into a yard they can go onward as received after inspection, change of crews and incidental work, without being broken up. For this class of trains a by-pass line from the receiving yard to the forwarding yard unobstructed by the usual yard work, should be provided. For separating the cars of trains which must be broken, there is required such a number of tracks as the number of classifications suggest, after considering the influence of acceptable operating demands, the yard space available, the second switching needed and local conditions. Briefly, it may be said that the separating yard should be designed so that, so far as possible, all the separating of different cuts of cars be accomplished when first dropping them into the separating yards; and at the outlet end of the separating yard, the work so far as possible should be only that of bunching together these groups of cars from the different tracks into a train lot. In spite of the most favorable design, a certain amount of second switching at the outlet end of the separating yard is necessary to put cars into train order. If this "tail switching" aggregates a considerable amount of the traffic or must be done quickly, the cars should be taken to a second separating yard, more properly called a "grouping" yard, where the grouping into train order can be done without interfering with the functions of the main separating yard. This latter grouping yard is particularly needed where there is a large proportion of fast freight to be handled.

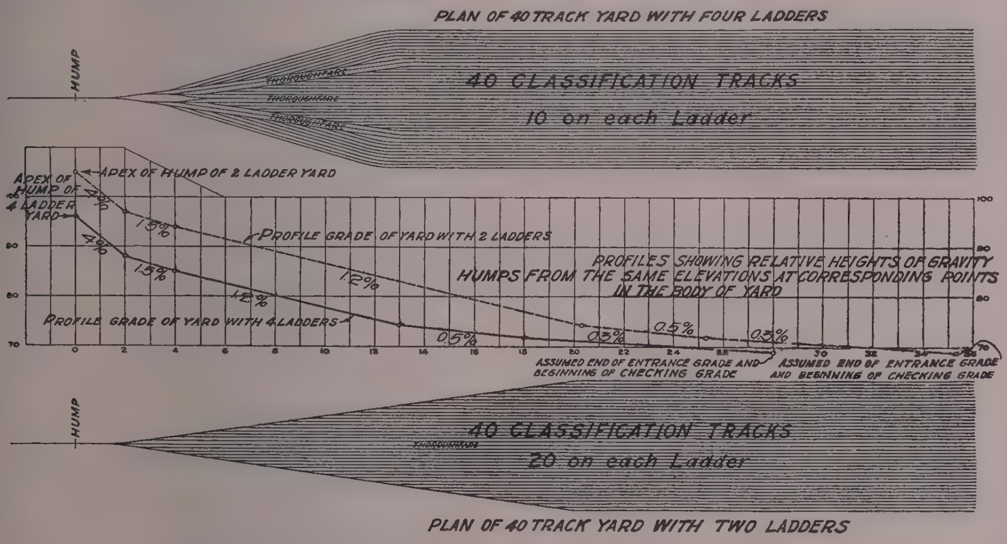
The length of the individual tracks in a separating yard is usually made equivalent to a maximum train length. The author believes that in nearly all cases, such tracks should be of about 60 per cent. the length of maximum trains, except where traffic is so regular and heavy that a maximum train length of cars which require no grouping into train order can be expected to accumulate within the time limits that such cars can properly be held before forwarding. This belief is based upon the unfavorable working of long tracks in existing yards examined by the author, and upon the theory that a classifying or separating yard is not a storage yard. That portion of the traffic that is held for bills or is unconsigned should be moved to a "hold" yard, as earlier outlined. All other freight should be separated, made up into trains and forwarded as a continuous movement. By so handling the train make-up work, there is a minimum delay to the cars and a smaller force of engines and men is needed, than if the work were concentrated after certain intervals of waiting for train lots of a single character to accumulate. Granting that this general statement of conditions applies to a given freight terminal, it is clear that no good end would be served by constructing long tracks in the particular separating yards, and it is likewise clear that much more rapid coupling together of accumulations of cars on each of a number of tracks can be done if those tracks are of moderate length than if they are of the length of a maximum train. Furthermore, it is less costly to construct and maintain a yard of moderate length separating tracks, than of longer ones, whether the yard be on a level grade or a gravity yard; similarly, it is less costly to separate trains into a yard of short tracks than of long ones.

The Forwarding Yard.—When a train is made up, it is taken to the forwarding yard where the air brakes are tested and coupled together, and the caboose and road engine coupled on. For this purpose is required tracks to hold the maximum lengths of made-up trains; these tracks in turn should have crossovers to hold two short trains on a single track. Lines of compressed air pipe should be provided. The caboose tracks should be close to one end of this yard. The author sees no preference as to the end of the yard where these tracks are placed, if skill is used in designing them. Thoroughfare tracks must be provided in sufficient number so that there can be no friction or delay in the pulling of made-up trains from the separating yards into the forwarding yard, and in the caboose and road engine movements.

General Details.—The angle or frogs generally used in yard tracks have been one in six and one in seven. When engines and cars were of comparatively light weight and the purchase of land limited to the smallest tracts that would admit of a working arrangement, there was justification for such angles. Since the Motive Power Departments began flanging all driver wheels, and the weight of engines has increased so much, the sharp leads required by these short angle frogs have been expensive and difficult to maintain, and derailments much increased. In a terminal yard where switching is constant, no frog of lighter angle than No. 8 should be permitted, and this frog only in the portions where the work is done exclusively by yard switch engines. The yard and road engines of the present day will frequently derail themselves on a No. 8 lead in perfect condition. In the receiving and forwarding yards, where the road engines must move, and in the approaches to the humps of gravity yards, the frogs should be No. 9 at the sharpest and No. 10 if practicable. In the ladder leads of separation yards operated by gravity, the curvature of the switch leads must not be such as to bind the cars running around them; a No. 8 frog is the sharpest justifiable, and No. 9 the preferable angle at this point.

Ladder leads should be as short as business permits, and the body tracks that one ladder cannot well control should be coupled to another ladder. It is generally conceded by operating men that a single switch engine cannot economically switch more than eight tracks. This rule would make that number the maximum number of body tracks to couple into a single drill track. Plate 2 shows a combination of three units of eight tracks per ladder illustrating the simplest type of classifying yards. In such an arrangement three engines could be switching continually without friction. Before accepting the above rule as conclusive in a given case, the number of separations required to put a train into proper order for forward movement must be considered. Conditions often require fifteen to twenty classifications to make up cars into train order, and these conditions must be met satisfactorily, if economical and efficient work is to be secured. At such points, if the separation work is to be handled by the push and pull method, two drilling leads can be designed with half the total number of classification tracks needed, coupled to each ladder; between these two drill tracks should be placed two receiving tracks common to each drill. Upon these special receiving tracks can be placed the overflow groups from one side that are to be later grouped on the other side and vice versa. This, of course, means re-switching, but there is no better solution of this difficulty, and the usual custom is more disadvantageous. Fig. 3 indicates a combination of two units of eight tracks per ladder with the two common tracks between for receiving the overflow cars from either side to meet such conditions.

In the hump yard system, the above rules do not obtain in the gravity portion of the separating yard. Here the motive force that starts each car and moves it forward into and partly through the separating yard, is gravity only. If the track arrangement and adjustment of gravity ratios beyond the apex are properly designed, the cars will run over a single track throat into the respective tracks of the separating yard faster than it is physically possible to bring them to the apex by the most advantageous track arrangement. Accordingly, there is no object in providing more than a single track throat to such a yard. The track arrangement should be based upon coupling to a single ladder not more than ten tracks in the very largest yard, and not more than six tracks, if possible, in other yards. It is seldom advisable to put more than four ladders in a yard, owing to the extra curvature involved in the tracks from the fifth and sixth ladders. This arrangement of four ladders is shown in Fig. 4 in comparison with two ladders for the same number of body tracks, and a profile for each, all drawn to the same scale and for similar operating conditions. The advantage of the four ladder scheme is manifest.


PLAN OF 40 TRACK YARD WITH FOUR LADDERS
HUMP
THOROUGHFARE
THOROUGHFARE
THOROUGHFARE
40 CLASSIFICATION TRACKS
10 on each Ladder
APEX OF HUMP OF 4 LADDER YARD
APEX OF HUMP OF 2 LADDER YARD
4%
1.5%
PROFILE GRADE OF YARD WITH 2 LADDERS
4%
1.5%
1.2%
1.2%
PROFILES SHOWING RELATIVE HEIGHTS OF GRAVITY HUMPS FROM THE SAME ELEVATIONS AT CORRESPONDING POINTS IN THE BODY OF YARD
PROFILE GRADE OF YARD WITH 4 LADDERS
0.5%
0.3%
0.5%
0.3%
100
90
80
70
0
2
4
6
8
10
12
14
16
18
20
22
24
30
32
34
ASSUMED END OF ENTRANCE GRADE AND BEGINNING OF CHECKING GRADE
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HUMP
THOROUGHFARE
40 CLASSIFICATION TRACKS
20 on each Ladder
PLAN OF 40 TRACK YARD WITH TWO LADDERS

Fig. 4. Comparison of Two and Four-Ladder Units.

In a hump yard the ladder switches at the entrances of the body tracks can be operated, either automatically from a tower at the throat of the yard, or by individual switch tenders. Excellent electro-pneumatic systems for handling these switches are used at various large yards, satisfactorily to the operating officers, and switch tenders are used at other yards with even greater satisfaction. The electro-pneumatic method is the more economical of the two, but is slower in operation.

In a busy yard there is distinct economy in providing an engine or trolley car to bring the switchmen back to the hump after riding a car to place. Usually some old light engine is assigned to this work. A trolley car is probably much the cheapest device for this work. For the movement of these cars a separate track should be provided at about midway of the yard; if the yard is a large one, two such tracks may be advisable, with two trolley cars or engines.

There are few questions in yard design more annoying than the proper location for the track scale. At terminal points, where large yards are needed, there is usually a considerable proportion of the total business to be weighed. If this percentage justifies it, the scales can be placed on the hump alongside of and parallel with the regular entrance track to the separating yard, so that the trains containing weigh cars can pass over the scale as they enter the yard. This is the quickest method of weighing. It is, however, a distinct misfortune to all other traffic to place the scales on the hump, as the adjustment of gravity ratios to properly move cars for weighing is not the most advantageous for other freight. The grades that are suitable for a plain throat track, free from scales, will permit the classification of cars faster than it is possible to bring them up the hump. For this reason it is well to locate the scales elsewhere than on the hump.

In developing plans to be submitted for the Buffalo Terminal Yards of the New York Central Lines, where the proportion of cars to be weighed was unusually small, the following scheme was developed: a scale was placed at the mid-length of an independent track, extending alongside the general separation yard from its outlet backward to the receiving yard. The weigh cars were to collect on a track in the separating yard up to the capacity of an engine to handle readily. They are then pulled out from the separating yard, and pushed backward to the scale track, and weighed as they move over the scale towards the receiving yards. They are then ready for re-classification for destination. The backup movement involved in this scheme of weighing is unfortunate, but is a much less evil than is involved in placing the scale on the hump. An improvement in the above scheme for handling light business was suggested for the Buffalo Terminal, by Mr. R. O. Rote, Principal Assistant Engineer, L. S. & M. S. Ry. The scale was placed at the mid-length of the outside body track of the general separating yard, and the particular gravity ladder running from the throat of the yard to this track was connected to a thoroughfare track by a trailing switch. After the upper end of the gravity scale track was filled from the scales to this trailing switch, a yard engine ran through to the cars, pushed them over the scales, then reversed, pulling them back, via the outside thoroughfare around the hump to the receiving yard, and reversing again, pushed them over the hump. This movement interferes slightly with yard operation but can usually be performed to fit in with other work smoothly.

Gravity Ratios.—The movement of a train of cars up and over a gravity hump, is for the purpose of placing the cars at such a height as to secure, by the aid of gravity, for each cut of cars, a quick start forward as the cut passes beyond the apex of the hump, and momentum sufficient to carry the cut onward through the arrangement of switches into the proper track in the classifying yard, and onward through this track until the lessened grade of the body of the classifying yard causes the cut of cars to stop from the combined friction of the car journals, the resistance due to low joints, poor line and worn rail usual in yard tracks.

The initial start of a cut of cars is caused by the grade placed just beyond the summit of the hump. This starting grade is usually called the "momentum" grade; and as this entrance point controls all movements into the classification yard, any delay at this point would to that extent lessen the operating capacity of the yard, regardless of favorable arrangements elsewhere. Furthermore, if the momentum imparted is not sufficient to carry the car through the distance it must run at the best rate of speed consistent with safe operation, the yard is again limited in capacity. Accordingly, the grade must be sufficient to start the cut of cars quickly forward, and it must impart sufficient momentum to keep the car going. This momentum should theoretically be assisted by sufficient grade beyond the limits of the hump grade to enable the car to run over the switches at the throat of the yard and in the ladder leads and around the curves at these points, until the cut reaches the proper destination track of the yard at the uniform speed, but not to increase the rate of speed. This grade, properly called the "continuing" grade, is an important feature, as the lagging of cars on the ladder leads, resulting from insufficient grade, would limit to that extent the operating capacity of the yards, and in most yards does do so. Other considerations, however, affect a decision as to this advisable gradient, and compel the proper rate to be exceeded to meet difficulties of operation.

Once in on the destination track of the separating yard, the car should have sufficient momentum to carry it well onward toward the out-going end; and in this latter portion, it should be stopped by the friction of its own movement by lessening or discontinuing the grades. To assist the car in keeping its momentum in the earlier part of this run through the yard, a few hundred feet of grade equal to the friction of the car journals and track condition is provided. This grade is the "drifting" grade. The "checking" grade that follows is very largely determined by the length of the individual tracks of the classifying yard, so that cars may not be stopped too early.

In deciding what rates of descent will, by the force of gravity, cause the cars to move as above outlined, a number of conditions affecting operation must be considered. In addition to the theoretical grade required to overcome the ordinary rolling friction of cars on tangent, must be added compensation for curvature of switch leads, compensation for the friction due to low joints, worn rails, and inferior line unavoidable in yards; also the extra force of wind against cars on the high portion of the yard must be provided for, and at the hump, in addition to all these considerations, the grade must be adjusted to give a quick start forward. Also, there must be considered the effect of low temperatures of the winter season on the car journals, and the still more inconvenient feature introduced by the occasional hard running car. Furthermore, empty cars start more slowly, run harder and are more retarded by wind pressure, than loaded cars.

Accordingly, in selecting the combination of grades for a given yard, after ascertaining the classes of traffic to be handled, and the special handling involved, the final decision as to the gravity ratios is based on those that will satisfactorily move the hard running cars under adverse conditions of the weather, wind, and track;

GRADES FOR GRAVITY YARDS.

	Northern Climate.	Southern Climate.
Momentum grade for loaded cars	200 ft. of 3 per cent.	200 ft. of 2.5 per cent.
Momentum grade for empty cars	200 ft. of 4 per cent.	200 ft. of 3.0 per cent.
Ladder grade for loaded cars	0.9 per cent.	0.7 per cent.
Ladder grade for empty cars	1.2 "	1.0 "
Continuing grade for loaded cars	0.3 "	0.2 "
Continuing grade for empty cars	0.4 "	0.3 "
Checking grade	0.0 to 0.2	0.0 to 0.2 "

the free running car, if unbraked, would gain a higher speed on such grades than advisable for safe operation, and the brakes are depended upon for this checking. The momentum grades that have been used, vary from 0.75 per cent. to 7.0 per cent. for a distance of one hundred feet or more; ladder grades have varied from 0.5 per cent. to 2.0 per cent.; drifting grades have been the usual theoretical rate of 0.4 to 0.5 per cent., and the checking grade has varied from a level to 0.3 per cent. With all these considerations must be balanced the danger of smashing cars, due to possible excessive gradients and the failure of brakes or their improper application.

After consideration of these matters and examination of the actual working, day and night, good weather and bad, of the principal gravity yards of this country the author respectfully recommends the rates of the accompanying table, upon which was based the combination of grades for the Dupo yards of the Gould System. If the scale is placed on the hump a separate hump track with a grade flattened at the scale should be used.

In case curvature exceeding eight degrees per hundred feet is used in any switch leads from the hump downward, compensate for the excess over eight degrees beyond the grades above suggested at the rate of 0.06 per cent. per degree; and in case of any curvature in the ladder track or body tracks of the separating yards, it should be compensated for at the rate of 0.04 per cent. per degree. Instead of the usual method of compensation, the friction of curvature of switch leads can be provided for by dropping the body tracks downward by a stiff vertical curve just beyond the end of the frog.

The recommendation of compensation for curvature is the result of observation of the lagging of cars in yards where compensation has been omitted. The rate of compensation is placed higher than for main track because of the poorer conditions that prevail in yard track. No less important than the adoption of proper ratios of grade is the placing of the apex of the hump as close as possible to the entrance of the yard; so vital is this consideration that a yard, correct in all other respects, will be a failure if this point is ignored.

These conclusions are based upon the examination of 13 of the most efficient gravity yards in the United States.

General Arrangement and Auxiliary Facilities.—It need hardly be said that the relative physical position of the receiving yard, the separating yard and the forwarding yard should be such that the movement of cars will be forward toward destination. This calls for a tract of land from one to four or five miles in length, which is often impracticable to secure at a justifiable price. This rule can be violated apparently with impunity, and still by good design in the yard arrangement, not appreciably delay traffic. The skill with which the general principles of yard design are adapted to a given point, determines the efficiency of a yard. All the demands of a fairly busy point can be met by a yard of eight body tracks and the auxiliary facilities under good arrangement.

Figs. 2 and 3 show the arrangement of drilling lead and body tracks of these simpler types of yards, to be embodied in the design of a small yard for a particular point. These give eight tracks as the advisable number on a single drill track. Such an arrangement makes one body track a receiving track, another body track the forwarding track upon which the new train is made up, and assigns the other six tracks for the classification work. No attempt has been made to more than show the units of the advisable arrangement for classifying. The amount of elaboration of these units, the addition of other tracks at either end to act as receiving and forwarding tracks, and other increased construction, all depends on the amount of business anticipated.

The special work to be done in terminal yards, consisting of transferring, rearranging, and consolidating freight, cannot be overlooked except at a distinct disadvantage. Properly handled, it favorably affects the tonnage showing, the time showing, and the economy of operation. For its convenience should be furnished a sufficient number of parallel tracks, with a covered transfer platform at some central point, and individual platforms also between each two tracks. At the end of the covered platform should be built sufficient warehousing to hold freight without bills, "over" freight, freight not completely loaded at the close of work at night, gang-planks, trucks, and for the conveniences for the truckmen, check clerks and bill clerks. A transfer crane is needed for lifting heavy loads for re-adjustment or transfer.

For solid trains requiring icing, the road crew should be able to take the train direct to the icing plant without stopping in or running through the receiving yard. For partial train lots, the movement must be over the hump of the separating yard, and for partial train lots, with the perishable freight bunched behind the engine, direct and quick access from the outlet end of the receiving yard to the icing plant is essential, and in turn convenient outlet from the icing plant to the forwarding yard is needed. It is not wise to attempt the icing of more than twenty-five cars at a time on each track, owing to the melting of ice in long hauls in trucks. Accordingly, the ideal arrangement is for platforms one thousand feet long, with an equal length of icing track beyond each end, so a lot of twenty-five cars, iced can be moved on ahead, and a second lot be quickly brought up to the platforms from the rear. The dimensions of the house itself are controlled by the storage capacity required. It should be built in units or pockets that can be added to as greater capacity is required.

Yard work is dangerous, difficult and slow, during the hours of darkness and during fog. Electric lights are frequently used for yard illumination, and the switchmen supplement these by leaving a lantern on the ground opposite the end of the last car on each track. The electric lights, as ordinarily used, are not effective, and the cars are handled slowly as a result. To overcome this trouble on the humps and ladders, Mr. M. E. Shire, Engineer in Charge, of the "Clearing Yards," Chicago, has developed a device like the reflector of a locomotive headlight; each light is equipped with one of these, and it is placed so the rays of light are directed toward the important channels of the work. The classification yards are most in need of such a lighting arrangement, and as there are no reverse movements in this yard, not even the slight disadvantage of lines of clear light shining at times in the faces of the switchmen is experienced.

In the body of the classification yard these lights are needed in greater quantity, and arranged to sweep the yard at different angles; on the outlet ladders, and in the other yards of the system, the reflector is undesirable as the switching is equally backward and forward in direction. Accordingly, the effective arrangement in these places is a general diffused light reflected downward only. The details of the lighting arrangement constitute in themselves material sufficient for a separate report. The writer has not seen any adequate lighting arrangement in use in any yard so far examined, and regards this detail as one of distinct importance.

A discreet engineer tries to perfect his methods of design and construction, by noting other men's work, profiting by the lessons to be learned both from successful portions, and from the unsuccessful portions. For this reason, it may be well to insert cautionary words here to show what points in yards now operated, have proven clearly undesirable.

Do not attempt to design any yard until thorough study has been made of the business to be handled by that yard; then make the best guess possible at the amount and character of business that can be anticipated for the future. Work out a plan for handling this future business; for the present arrangement, plan to build the proper proportion of the final plan, so far as possible on the lines of the final scheme. Do not limit the land purchases so as to interfere with a good working arrangement. Do not attempt to adopt types and methods of design for comparatively small amounts of business, that are successful only with heavy business. For instance, there is no justification for building a hump yard to handle the general merchandise, lumber, grain and coal traffic of the ordinary division station, or ordinary terminal station. The hump yards that have been built at a number of points for comparatively small business, are so far as observed, costly and unsatisfactorily in operation and the best operating men agree that the hump yard type is as inadvisable for moderate business as it is essential for heavy business.

Do not neglect the proper lighting of a yard for night work until the yard is under construction or later. The best location for the necessary light carrying poles should be provided by spreading the tracks to admit them without peril to trainmen at work. Note carefully the methods of conserving and directing the rays of light, and adapt them to each portion of the proposed yard to suit the respective switching movement.

Do not permit curvature in excess of eight degrees per station in any important parts of the yard; do not fail to compensate for curvature in hump and gravity yards, in the portion where gravity is used as motive power.

Do not fail to arrange for surface drainage.

Do not fail to provide sufficient spacing of tracks for convenience in giving and seeing signals, and throwing switches, and the other work of the yard.

Do not fail to provide sufficient drilling tracks so that switch engines can work freely without friction or interference with each other, or with incoming or outgoing trains.

Do not even in the smallest yard attempt to have the car repairs made, or cabooses or wrecking outfit stored, on tracks in the body of the yard, —put them on tracks of their own outside.

Do not lightly decide where the scale shall be placed. Give this item the most careful thought.

Do not make the classification tracks too long, as delay and extra expense in switching is thereby occasioned.

Do not couple too many body tracks to a single ladder.

Do not forget that a yard should be as elastic as possible for present use, and so design that future enlargement will be on a harmonious scheme.

The yard illustrated in the accompanying drawing was designed by the author for the Missouri Pacific system at Dupo, Ill. Portions of the yard have been in use since about October 1st, 1905. About one-half the trackage called for on this plan is to be built as the first installment of the terminal, the balance being provision for the future.

The Septic Tank of the Belleville, Ill., Sewerage System.

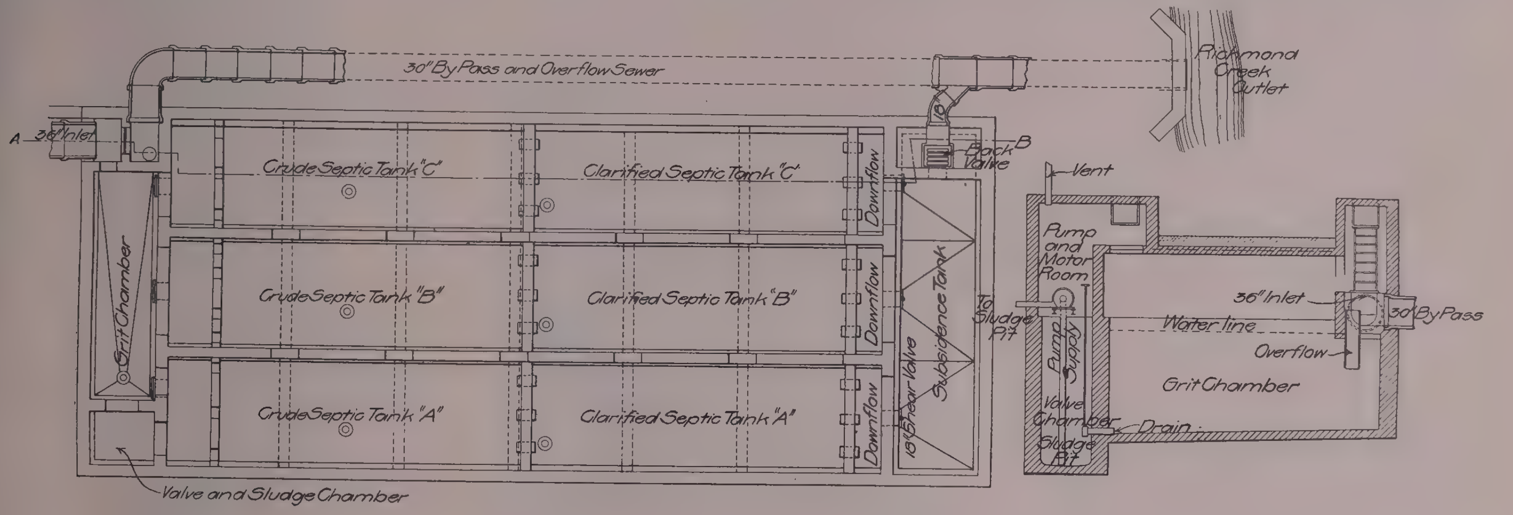
A septic tank with a capacity for treating the normal dry weather flow from a sewerage system serving a population of 30,000 was placed in service in November, last, at Belleville, Ill. Belleville has a population of approximately 25,000 and is 15 miles inland from the Mississippi River at St. Louis, Mo. The site of the city is for the most part on fairly high ground between two forks of Richland Creek, which join just below the city. The sewerage system is designed to carry the combined domestic and storm-water flows, and formerly had a number of outlets within the city into the two forks of the creek. The flow in these forks was sufficient during considerable portions of the year to carry away the sewage discharged into them without much offense to the districts along them. One of the forks is generally dry, however, during at least a part of the summer, and the other has a very low flow in dry weather. Under these conditions the beds of the streams had become badly fouled, although by far the largest part of the sewage was discharged into the fork of the creek which always has some water flowing in it. After careful investigation of the conditions, two intercepting sewers were built, one down the valley of each stream and the discharge from the various outlet sewers diverted into these intercepting mains. The latter are merged together below the city and continue as one 36-in. outfall sewer for 1,500 ft. to the septic tank, which is located on the only available site, a low flat piece of ground along the bank of the creek. This site is flooded by extreme high water in the creek, but the tank is closed and is arranged so none of the flood waters can ever enter it.

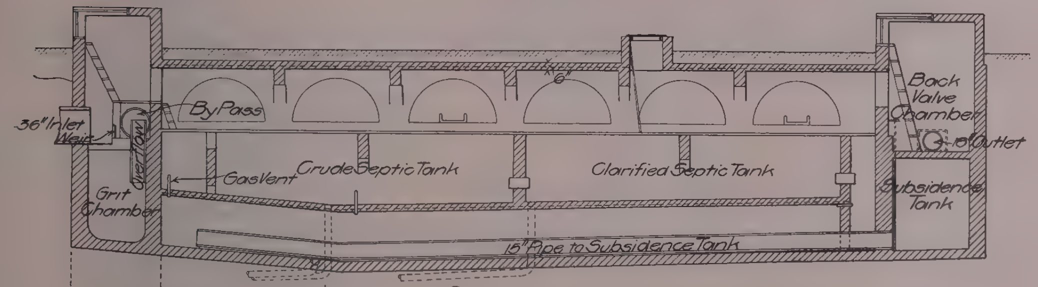
The tank is entirely underground and is built throughout of concrete, steel reinforcement being employed where necessary. It is 34 ft. 4 in. x 84 ft. in plan and has an extreme height of 19.5 ft., excepting several manholes which extend through the covering of soil over the tank. The tops of these manholes are well above flood level and afford means of access to the interior of the tank. The latter is separated into three distinct longitudinal divisions, with a grit chamber placed transversely across the inlet end and a subsidence tank across the outlet end. The longitudinal divisions are also each separated into an upper and a lower compartment by a horizontal 6-in. reinforced concrete floor, 3.5 ft. above the main floor of the tank. The reinforced-concrete roof of the tank is carried by transverse arches between the walls which separate the longitudinal divisions.

The 36-in. outfall sewer discharges into a 4 x 6-ft. chamber at one corner of the inlet end of the tank, the invert of that sewer in the chamber being just above the water line in the tank. As the latter is designed to treat the dry weather flow only, a 30-in. by-pass pipe leads out of the inlet chamber and carries directly to the creek whatever quantity of flow cannot pass through an orifice 18 in. in diameter. An opening of that size, fitted with a sluice gate, is placed in the side of the inlet chamber and all flows up to the capacity of this orifice are passed through the latter. A weir, with its crest level with the top of this orifice, is set in the 30-in. by-pass in the chamber, so all the flow from the 36-in. sewer passes through the tank until the quantity exceeds the capacity of the 18-in. orifice when the excess spills over the weir into the 30-in. by-pass. A 12-in. pipe is also set vertically in the floor of the inlet chamber, with its top 6 in. above the weir, and acts as an overflow which discharges into the grit chamber and prevents the inlet chamber being flooded. The latter chamber is 11 ft. high and is covered by a concrete roof, a manhole through this roof providing an entrance to it.

The grit chamber is 5 x 25 ft. in plan and has an 8.5 to 9.5 ft. depth of water, its bottom being sloped down from the inlet end to a drain into a valve chamber and sludge pit at the opposite end. The velocity of the sewage being greatly reduced in this chamber, the heavier matters brought in are deposited in the chamber and may be drawn off through the drain into the sludge pit. A 15-in. circular orifice leads from the chamber into each of the upper compartments of the longitudinal divisions of the tank; these orifices are not submerged, but are set so the sewage overflows from the chamber into the tank. Each orifice is fitted with a sluice gate so the flow into any division of the tank may be regulated or stopped.

The upper compartments of the three longitudinal divisions of the tank are 10 ft. x 65 ft. 8 in. in plan, and have from 4.5 to 5.5 ft. of water in them. A 9-in. concrete wall is placed across each of these compartments, 4 ft. from the inlet end, and has a series of openings in it which diffuse the flow of the incoming sewage. Three 15-in. semi-circular openings are spaced equally across each of these walls at the bottom and three overflow openings of the same size are spaced across them at the top. A second transverse wall, 13 in. thick, is built across each of the upper compartments, 28 ft. from the first wall and forms an intermediate compartment, 10 x 28 ft. in plan, in which the preliminary septic processes occur in the sewage. A 13-in. transverse beam across this compartment at the middle has its lower edge submerged 18 in. below the water surface to prevent surface currents. Three 10-in. circular openings through the 13-in. wall across the end of each of these intermediate compartments are submerged 3 ft. below the water level in the latter and provide the only outlet into the compartments beyond, so a scum is afforded a good opportunity to form and the heavy matters not intercepted in the grit chamber are deposited before the sewage passes through the submerged outlets from these intermediate compartments, which are called the crude septic tanks. The floor of each of the latter is sloped to a 6-in. drain pipe leading to the valve chamber and sludge pit. The clarified sewage undergoes additional septic action in the part of the upper compartment beyond the 13-in. transverse dividing wall. A partially submerged beam is also placed transversely across the center of this part of the upper compartments to hold the scum in place. The outlets from the latter are three 10-in. circular orifices, 3 ft. below the surface, in 9-in. cross walls, 2.5 ft. from the end walls of the compartments. The floor of each of the second intermediate compartments is sloped to a 6-in. drain pipe leading to the sludge pit. The roof of the tank is 7 ft. above the water level in the upper compartments, and a walk is laid on the various walls so all parts of the tank are accessible for inspection.





Longitudinal Section at A-B

Plan and Sections of the Septic Tank of the Sewerage System of Belleville, Ill.

The spaces between the end walls of the compartments and the 9-in. cross walls containing the outlet orifices connect at the bottom in each case with the lower compartment of each longitudinal division of the tank. A 15-in. pipe, with tight joints, is laid the length of each of the lower compartments, and is open at the end opposite from the connection with the upper compartment; the other end of each of these pipes passes through the wall at the outlet end of the longitudinal divisions of the tank and opens into the subsidence tank. The effluent from the upper compartments is thus required to pass the full length of lower compartments and back in the 15-in. pipes to the subsidence tank, the organic matter in it being additionally broken up and a large part of the finely divided particles which generally pass from a septic tank being settled out in this passage. The floors of these lower compartments are sloped to a drain leading to the sludge pit. Any gas that may collect at the high points in these compartments is allowed to escape through 2-in. pipes placed through the floor of the upper compartments. The end of each 15-in. pipe leading into the subsidence basin is controlled in the latter by a 15-in. sluice gate.

The subsidence tank is 8 x 25 ft. in plan, the effluent overflowing from the top of it into an 18-in. pipe connecting with the 30-in. by-pass leading to the creek. A check valve is placed in this 18-in. pipe to prevent water backing up in the tank during floods in the creek.

The pit into which the sludge and sediment from the various compartments of the tank are discharged through the drains that have been mentioned, has its bottom 3 ft. below the lowest point of the tank. A 4-in. centrifugal pump operated by a water motor is placed in a 6 x 10-ft. pump-room over the pit and may occasionally discharge the flow into the latter on a sludge bed on top of the embankment over the tank. A water motor instead of an electric motor was installed to drive this pump owing to the fact that the air in the pump room will always be moist.

The sides and bottom of the sludge bed, which is 14 x 25 ft. in plan, are of concrete. The bed contains a 2.5-ft. layer of gravel covered with a 2-ft. layer of sand. Two 6-in. pipe underdrains are laid in the gravel and connect with an 8-in. pipe leading to the creek. The tank has not required cleaning since it has been in service, but, when necessary, the plan is to clean one compartment at a time, and to pump the sludge on the bed. It is expected that several cleanings can be made before sufficient sludge is produced to necessitate the removal of the latter from the surface of the bed after the water has been drained from it.

The tank was designed and built by Messrs. Lewis & Kitchen, engineers and contractors of Chicago and Kansas City, for whom Mr. Fred P. Smith is consulting engineer. Mr. L. L. Harper is city engineer of Belleville.

The San Francisco Earthquake was but part of a series of connected earthquake phenomena extending along the entire western coast of the American continents, according to the report of Mr. F. Omori, Secretary of the Imperial Japanese Earthquake Investigation Committee. Within 7 years preceding the San Francisco disturbance there were seven great earthquakes in the region mentioned, the only gaps being at San Francisco and along the southern end of South America. These gaps were closed, making a continuous chain of disturbances from Alaska to Chile, by the California earthquake, and by the Valparaiso shocks of Aug. 17, 1906. The entire series of disturbances was due to tension along the whole western coast and now that equilibrium has been reached, Mr. Omori believes it is probable that there will be no great seismic activity in that region for some time.

The Sewage Disposal Works of Newton, New Jersey.

The sewerage system and sewage disposal works recently completed at Newton, N. J., include 7⅓ miles of sewers, varying in size from 15 to 8 in., and two separate sewage disposal plants, one of which, called the Clinton St. plant, receives the sewage delivered through 5½ miles of the new sewer system, and the other, called the Sparta St. plant, receives the remaining sewage. The construction of two separate disposal plants for a town with a population of 5,000 was necessitated by the unusual topography of Newton, which is located on a ridge, thus making it impossible to drain all the collecting sanitary sewers into one outfall. The Clinton St. and Sparta St. plants are on the northern and southern sides of the city, respectively, and are about 6,500 ft. apart. The ridge between the two plants is more than 40 ft. high and the difference in elevation of the land surface of the filters is less than 6 ft., the Sparta St. beds being the higher.

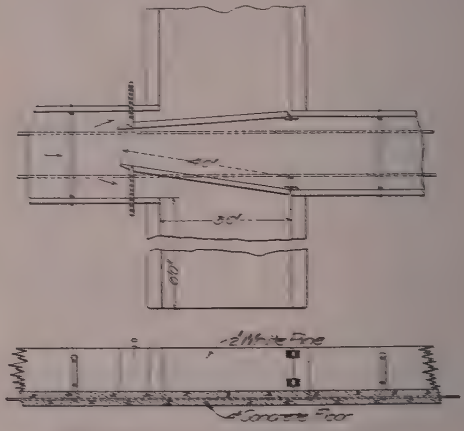
Partially Completed Cut-Out Chamber.

The minimum grades adopted for the Newton sewers are as follows: 8 in., 0.50 per cent.; 10 in., 0.32 per cent.; 12 in., 0.22 per cent.; 15 in., 0.16 per cent. They are designed to act as sanitary sewers exclusively. Flush tanks were built on all dead ends, those on grades exceeding 3 per cent. being flushing manholes and those on grades less than 3 per cent. being automatic flush tanks of the Rosewater type. Manholes were placed at all changes of grade and line and at all intersections and Y-branches for house connections were placed for each lot, these branches being sealed for future connection. The construction of these sewers involved the excavation of about 6,000 cu. yd. of rock, most of which was limestone, although in the higher parts of the town there was some slate and shale. The price bid for the construction of the sewers with all appurtenances was $35,040, with an additional charge of 75 cents per cu. yd. for rock excavation, which amounted to $4,500. These figures represent very nearly the cost of the sewers with the exception of the vitrified pipe, which the town furnished at a cost of $9,568.

The sewage of Newton may be called domestic in character, though it includes waste from three shoe factories, one silk mill and a creamery. From the shoe factories there is practically no manufacturing waste, except small quantities of liquid resulting from the soaking of leather. wastes from the silk mill are unimportant, except those from its dyeing establishment. To attempt to purify these dyeing wastes would make the purification of the domestic sewage much more difficult, as this waste when added to sewage is inimical to bacterial life. However, as these wastes have been in the past and are at present emptied into a swamp, where there is no objections to them, no attempt has been made to purify these liquids in the disposal plants. The quantity of waste received from the creamery is not a sufficiently large percentage of the total quantity of sewage to warrant the expectation that any trouble will arise from this source.

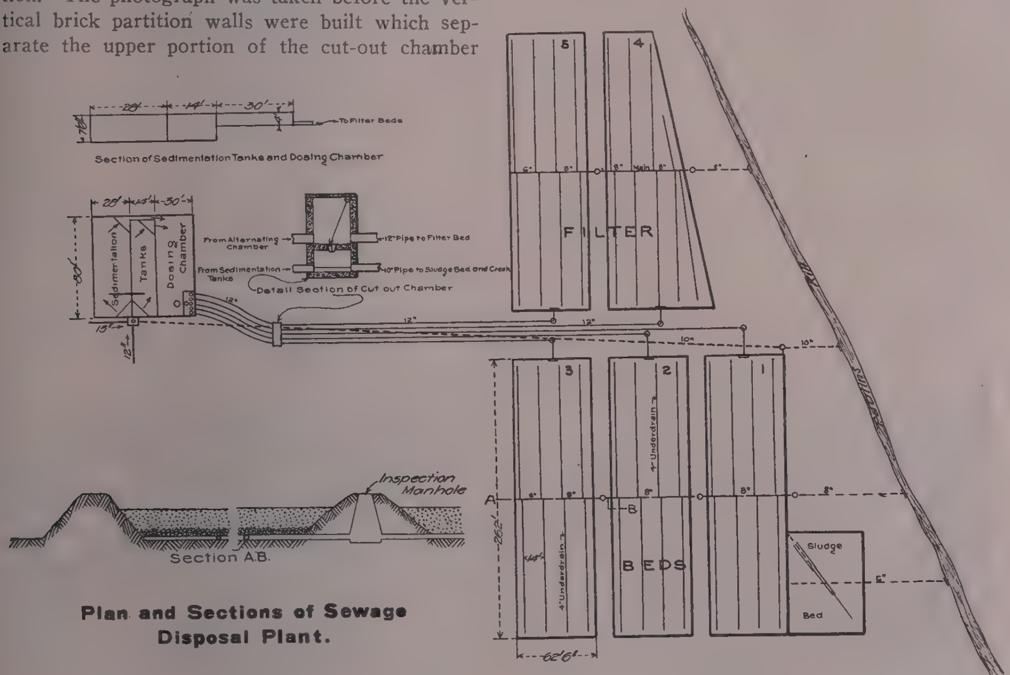
The larger or Clinton St. disposal plant is designed to care for a sewage flow of 297,500 gal. per day. This plant is shown in plan in an accompanying illustration. It consists of two contiguous reinforced concrete septic tanks 80x28 ft. and 80x14 ft. in plan, respectively, both tanks being 7½ ft. deep. Contiguous to the smaller septic tank, as shown on the plan, is a dosing chamber, 4 ft. deep and 80x30 ft. in plan. Both tanks and the dosing chamber as well are covered with a reinforced concrete roof, which is a little below the level of the ground surface.

Two outfall sewers, 12 in. and 15 in. in diameter reach the Clinton St. plant. These deliver sewage into a small detrius well located at the end of the two septic tanks, its center being on the line of the common wall between the two tanks. In the wall of each tank at the detrius well is an overflow weir provided with a sliding sheet-iron gate. Across the corners of each septic tank is a suspended baffle wall shown on the plan, the submerged aperture at the bottom of which is about 4 ft. high and 10 ft. long. There is also in each tank a brick baffle wall extending from top to bottom of the tank and one-half the distance across it. These baffles are placed near the inlet end of each tank and are calculated to insure the even distribution of the sewage flow. In one corner of the outlet end of each tank is a suspended baffle wall similar to those already described. The sewage in leaving the tank flows under this baffle and rising passes over an overflow weir provided with stop planks with which the height of the weir can be raised or lowered. The effluent from the larger septic tank passes into the dosing chamber through a concrete conduit built across the lower end of the smaller septic tank. The adjustable outlet weirs and the fact that either the large or small septic tank may be cut out or both tanks used at once, makes it possible to vary greatly the time of detention of the sewage in the septic tanks. It is expected that in general the sewage will require about 8 hours in passing through the septic tanks, and they have been designed with this in view.



Distributor for Sewage Filters.

In one corner of the dosing chamber is a small rectangular compartment known as the alternating chamber, from which five 12-in. mains lead out, each going to one of the five filter beds. The contents of the dosing chamber is periodically discharged into the alternating compartment by means of a siphon controlled by a float and air valve. The end of each of the 12-in. pipes in the alternating chamber is provided with a flap valve, and these five valves are so controlled that they are opened alternately and so that one of them is always open. The controlling device consists of a five-throw crank shaft placed over the alternating chamber above the flap valve. This shaft has its five cranks equally spaced in 360 deg. To each crank is attached a chain which passes to the flap valve directly below it. The shaft is rotated by means of a float and ratchet wheel arrangement, the float being in the dosing chamber proper. The ratchet wheel is so arranged that each time the contents of the dosing chamber is discharged the shaft is rotated one-fifth of a complete revolution, thus closing one flap valve and opening another. Between the dosing chamber and the filter bed is a cut-out chamber by means of which the flow may be diverted from any single filter bed or from any number of beds and allowed to pass through a 10-in. main into Paulins Kill. This cut-out chamber is clearly shown in the accompanying illustration. The photograph was taken before the vertical brick partition walls were built which separate the upper portion of the cut-out chamber into five compartments. The 10-in. waste main leading through the cut-out chamber also extends to the detrius well, in the bottom of which is a lift valve through which sand and grit can be washed into the 10-in. main and into the creek.



Plan and Sections of Sewage Disposal Plant.

The five filter beds have a total area of 1.83 acres and are arranged as shown in the accompanying illustration, each of the four rectangular beds being 262x62½ ft. in plan at the top surface of the sand. The effluent of each filter is collected by four longitudinal lines of 4-in. tile drains which empty into a discharge main 8 in. in diameter, except at its extreme upper end, where it is 6 in. in diameter, leading to the creek. On each of these discharge mains at the outflow side of each filter bed is an inspection manhole built in the filter bed embankment. The underdrains of each filter are covered with about 6 in. of 2-in. gravel, over which is 3 ft. of local sand, which was deposited in 6-in. layers. The sewage is to be applied to the beds at the rate of 160,000 gal. per acre per day.

Extending along the surface of each filter bed on its longitudinal center line is a distribution conduit, rectangular in cross-section and varying in width from 24 in. to 8 in. The effluent does not overflow the sides of this distributing trough, but at intervals is allowed to escape through its sides. By means of a device shown in an accompanying illustration, the flow through any of these side apertures may be closely regulated. The distribution trough has a concrete base and bottom and plank sides, which are held in place by U-shaped pieces of strap iron as shown in an accompanying cross-section.

The Sparta St. plant is designed to receive a flow of 127,500 gal. of sewage per day, and its filter bed has a total area of 0.8 acres. This plant has a single septic plant and a dosing chamber, both being built of brick and roofed with arches sprung between I-beams and reinforced. In design and operation the small plant is very much like the large one.

The sewerage system and both the sewage disposal plants were designed by Messrs. Williams, Proctor & Potts, of New York. The sewers were built by Messrs. Allen & Wolf, of Stanhope, N. J., and the disposal plants were constructed by Messrs. Hinman & Sproul, of Schenectady, N. Y., the contract price for these being $29,618.

The Erection of the Haverhill Bridge.

The highway bridge across the Merrimac River, at Haverhill, Mass., has a 32-ft. roadway, five 153½-ft. through pin-connected truss spans, and one 61-ft. plate girder span, weighing in all 1,618,000 lb. At the site the river has a hard gravel bottom, and the water is about 7 ft. deep at low tide, with a swift current. The falsework, about 40 ft. high, consisted of framed trestle bents, each made of three 12x12-in. vertical posts braced with 4x8-in. diagonals. The 12x12-in. caps, about 38 ft. long, were spliced in the middle with two wooden vertical scab plates, and were supported at this point by a third vertical post, which did not directly carry any part of the dead load of the bridge, but prevented undue deflection and vibration of the cap.

The first two spans of falsework were erected before the river was closed by ice, and the pieces of timber for them were handled singly by the travelers used later for the erection of the steel work. The caps were spliced on shore, floated to position and raised by the two booms of the traveler, which swung them into temporary position parallel and close to the last bent erected, which thus served as a working platform for assembling the bent. The vertical posts were also lifted separately by whip lines from the booms, which supported them until they could be made fast with scabs connected them to the cap. Transverse 6x12-in. sills, 7 ft. long, were secured flat-wise to the lower ends of the vertical posts and served to give them bearing on the hard gravel bed of the river. The lower ends of the transverse X-bracing were bolted to the bottoms of the vertical posts before the trestle bents were lowered into position and braced there. As each span was completed, the falsework under it was moved forward and placed under a span in advance. After the completion of the first two spans, the falsework was placed for the remaining three spans after the river had been closed by ice, which formed a working platform on which the men assembled the trestle bents which were lifted by the traveler. The 12-in. I-beam stringers of the permanent superstructure were temporarily used as falsework stringers to support the new spans and traveler during erection.

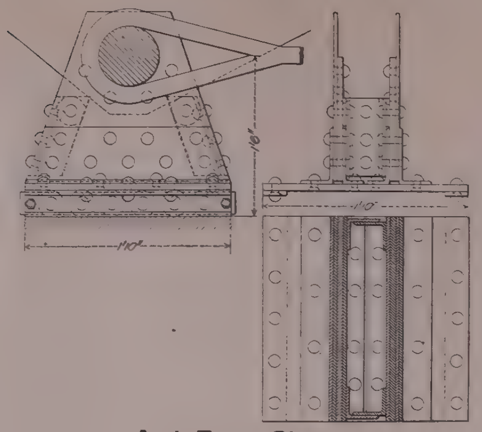
All steel was handled by an inside four-post timber tower traveler of somewhat unusual design. It had lower longitudinal sills about 25 ft. apart on centers, giving ample clearance inside the trusses 33 ft. apart on centers. The post was battered transversely so as nearly to overhang the upper chords, and the tops of the posts were connected by transverse caps 36 ft. long. The lower transverse struts were placed about 7 ft. above the rails, so as to afford clearance below them for material cars pushed in by hand on the service tracks laid between the traveler rails. The transverse X-bracing of the traveler was placed with the lower ends a little above the longitudinal sills so that it also gave ample clearance over the service tracks. The forward posts of the traveler served as masts for two 12x12-in., 40-ft. booms fitted with Chicago boom irons and operated by a two-drum, four-spool hoisting engine, which was not carried on the traveler, but was set on a horizontal timber platform, skidded forward from pier to pier as erection advanced.

The plate girder floorbeams weighing about 6 tons each were first brought in and put into position, after which the lower chords, vertical posts and diagonals were assembled, the lower chord panel points completely packed and their pins driven. The weight and width of the floorbeams gave them sufficient ability to hold the vertical posts safely in position without the latter being temporarily braced, and they were thus maintained until the top-chord sections were brought in, unloaded by the two booms, swung to position and placed on top of the vertical posts. It had at first been intended to distribute the top chord alongside the vertical posts, between them and the traveler rails, but this method was found unnecessary and the top chords were handled directly by the booms from the service cars. The bridge was erected at the rate of about one span per week by an average force of 30 men. Prof. G. F. Swain was the consulting engineer and the American Bridge Co. was the contractor for the fabrication and erection of the structure.

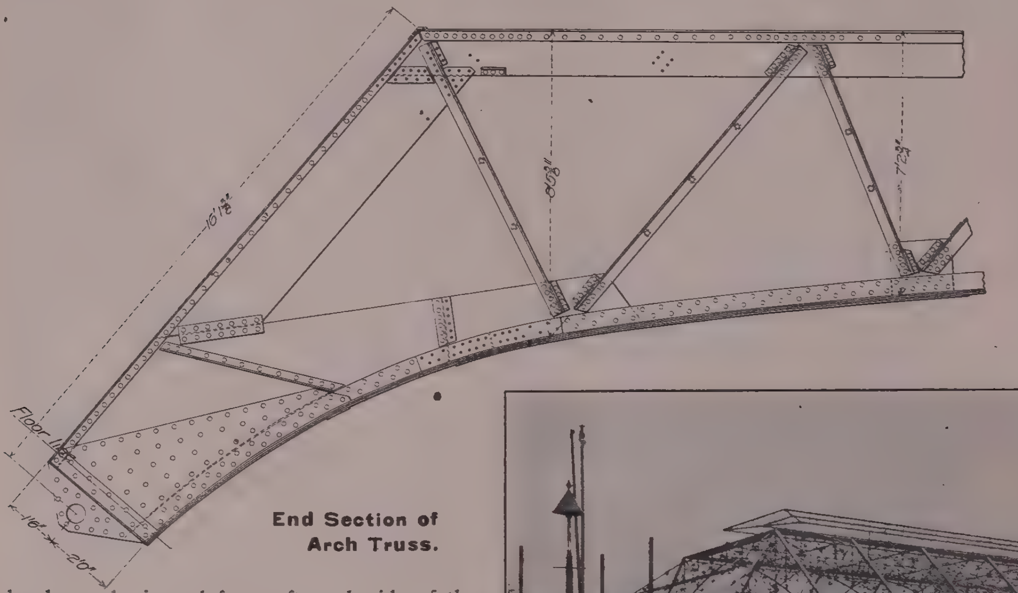
A Concrete Building in Milwaukee recently went through an accidental test that well shows the stability of such construction, when properly executed with good materials. The building has a concrete frame and walls, all the concrete being made with Dragon Portland cement, and there are numerous large windows and doors. An explosion of acetylene occurred in it on April 2, killing or injuring everybody within, and blowing the windows, doors and woodwork into pieces. An examination of the structure by a correspondent revealed no crack or blemish anywhere on the concrete. The effect of such explosions on brick and timber buildings is proved by the records of the National Fire Protection Association to be very destructive, which makes the showing by this concrete structure all the more creditable. It is not surprising, however, that the building withstood the test, for its monolithic nature specially fitted it to do so.

Providence Armory Drill Hall.

A 235x170-ft. steel drill hall, 70 ft. in extreme height, has recently been built with fronts on Cranston St. and Durfee St., Providence, between east and west head houses 235 ft. apart, which form the end walls of the drill room. It has a clear height of 64 ft. from the floor to the top chords of the trusses in the center, and is unobstructed by columns for the full width and length of the building. The roof is supported on the end or head house walls and on eight transverse three-hinge riveted arch trusses spaced 26 ft. 1 in. apart on centers. The lower chords of the semi-trusses are continuous circular curves described from two centers and intersecting at the crown to form a flat Gothic arch. The top chords are horizontal for 32 ft. each side of the center and thence slope downward at an inclination of about 1:1 to the top of the side longitudinal walls, where they intersect the vertical posts of the trusses about 15 ft. above the end pins. The ends of the roof trusses are built into the longitudinal side walls which, with the head house end walls and the roof, completely enclose the drill hall. Exterior buttresses in the side walls enclose the vertical ends of the arch trusses and are seated on the main piers which project beyond the inner and outer faces and afford bearings for the girder shoes and for the truss pedestals.

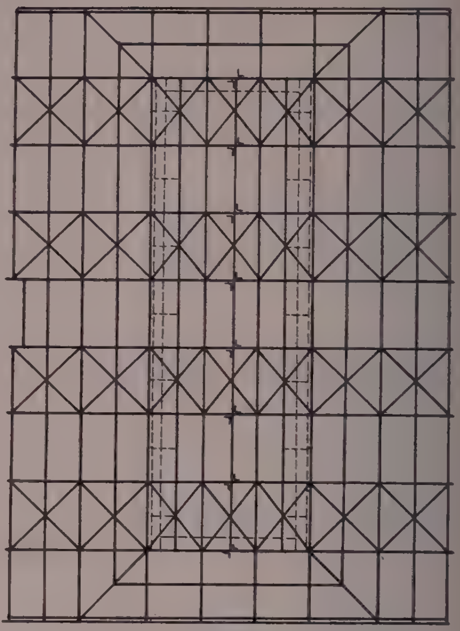


Arch Truss Shoe.

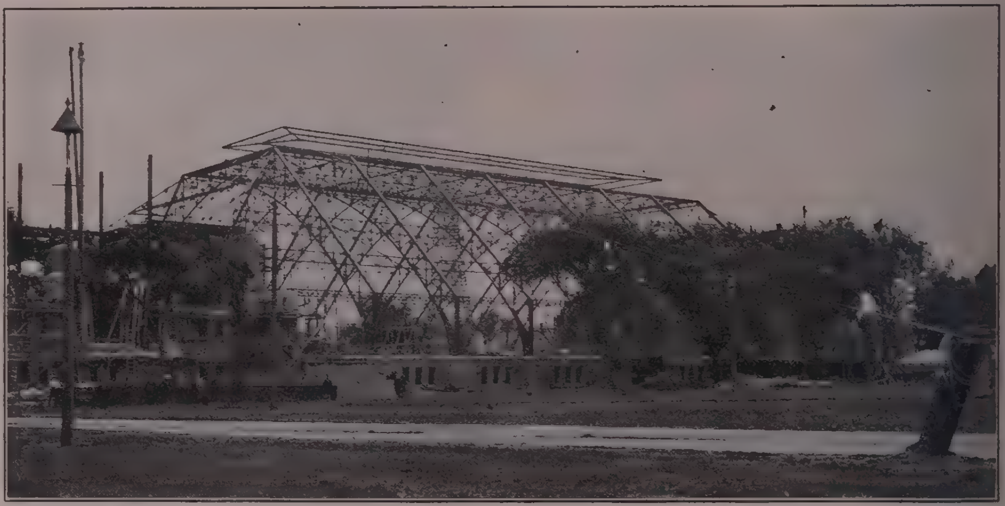


End Section of Arch Truss.

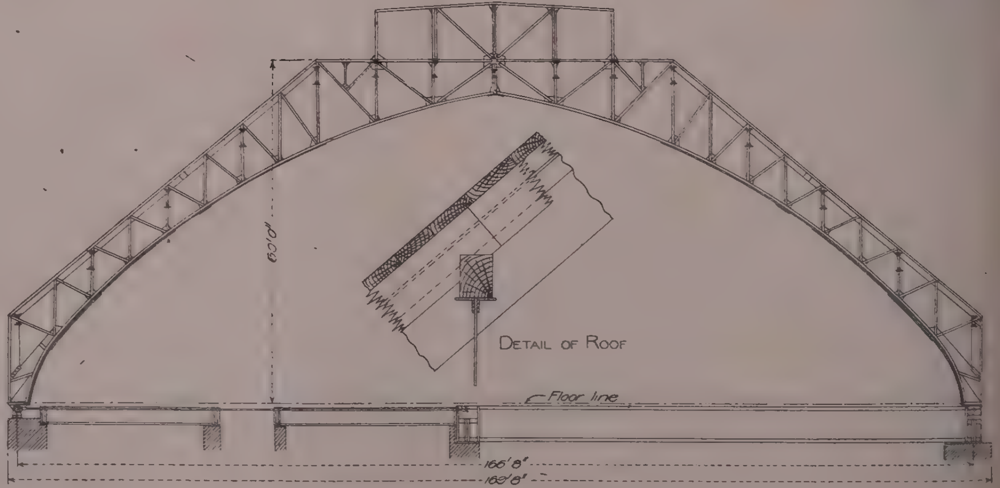
The area covered by the drill shed was excavated one story below street level to provide space for rifle range, storage, and other purposes. The drill hall floor is therefore supported on longitudinal trusses about 11 ft. apart carried by transverse plate girders in the planes of the roof trusses and having lengths of 30 to 90 ft. The girders are supported on the side wall piers and on two intermediate longitudinal walls about 9 ft. apart, between which the earth is not excavated. Fifteen lines of longitudinal trussed purlins are web connected with the roof trusses in the seven intermediate panels, each alternate panel being X-braced with angles in the planes of the top chords. In the end panels the center purlins are inclined downward from the roof trusses to the head houses to form a hiproof construction with diagonal jack-rafters at each end of the horizontal portions of the top chords of the main trusses. The 42x182½ ft. horizontal space in the center of the roof is surmounted by a 42x165-ft. steel frame monitor 19 ft. high with transverse bents 13 ft. apart supported in the planes of the roof trusses and intermediately by the purlins. The monitor frames are made with angles and channels and are knee-braced instead of having regular trusses.



Roof Plan.



Frame Work for Providence Armory Drill Hall.



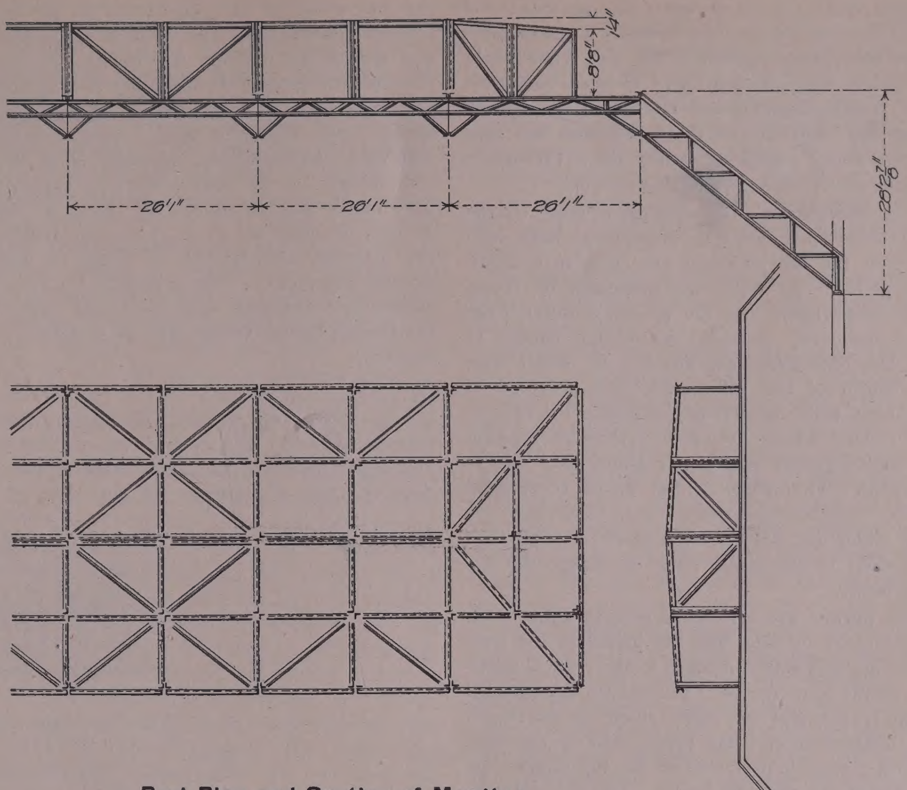
Transverse Section of Drill Hall.

The arch trusses have a rise of about 61 ft. between pin centers and have vertical depths of 6 ft. at the crown, about 15 ft. at the haunches and about 16 ft. at the end pins. The minimum depth of the truss is about 7½ ft. over all and the distance between the end and center pins is 103 ft. 1 9/16 in. The lower chords are uniformly curved to a radius of 130 ft. except for a short distance near the lower end where the radius is 32 ft. and the curve is nearly tangent with the vertical at the level of the skewback pin.

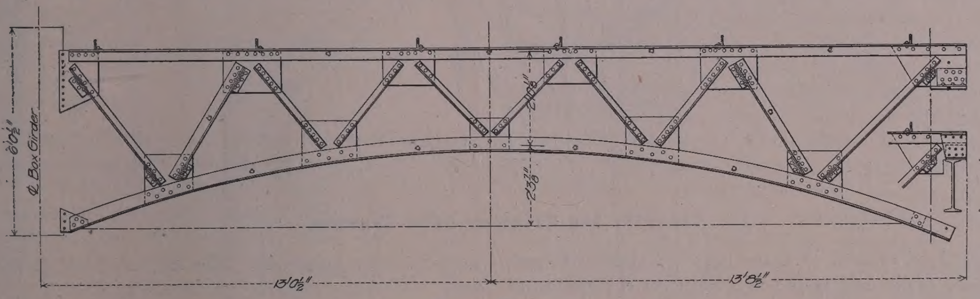
All of the truss members have cross sections made with pairs of angles riveted together back to back, except the sub-verticals and sub-diagonals which are made with single angles, and the center vertical post which has a cruciform cross section made with two pairs of angles. The horizontal portion of the top chord is made with a pair of 6x4x⅞-in. angles with web-connection plates riveted between their vertical flanges. The inclined portion of the top chord is made with two 4x3x⅜-in. flange angles and a 15x¾-in. web plate riveted between their vertical flanges. The bottom chord is made with 6x3½x⅜-in. angles reinforced with two 10x5/16-in. cover plates in the lower panels and with one 10x5/16-in. cover plate reduced to one 7½x¼-in. cover plate in the upper panels, the last two panels at the crown not having any reinforcement.

In the end or skewback panels, the vertical plates between both top and bottom chord angles have their widths increased, so that together they occupy about two-thirds of the entire area of the panel. They are made in sections of convenient size, with butt joints and double cover splice plates, and are braced near the center by a pair of nearly horizontal web stiffener angles. The lower end of the panel is also reinforced by a pair of ⅜-in. web plates making a total thickness of 1⅛-in. and giving a solid bearing on the skewback pin. All truss members were shipped separately, and assembled and field-riveted at the site, the connection plates being shop-riveted between the chord angles. The bottom chord angles were bent at the shops to a wooden template 16 ft. long with a center ordinate of 2 31/32 in.

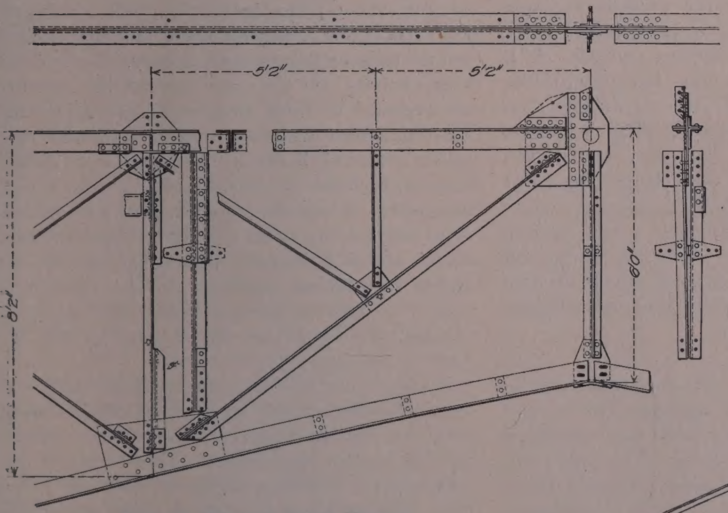
The crown hinge is made with 4½-in. pin engaging overlapping connection plates riveted to the top chords of adjacent semi-trusses. The adjacent bottom chords are connected at the crown by bolts engaging slotted holes in their flange angles and round holes in the connection plate at the foot of the vertical post. The main vertical members of the trusses have field riveted connections to the purlins and to their knee-braces. The skewback hinges of the arch trusses are made with 6½-in. pins, which at one end of each truss engage a riveted pedestal with an expansion bearing on the masonry pier. At the opposite end of the truss the pedestal is omitted and a fixed bearing is provided by the pin passing directly through the reinforced webs of box girder supporting the drill hall floor. The arch thrust is taken by compound horizontal tension members connecting the skewback pins of each truss. One end of this member is made with 1¾x1¾-in. rods with loop eyes, upset ends and sleeve nut adjustments. The main floor girders, 91 ft. 8 in. long and 6 ft. deep are utilized to form the other end of each tension member. Each of these girders has two ⅜-in. web plates spaced 11 in. apart, and each flange is made with two 6x⅝-in. angles and several 24-in. cover plates. The upper parts of the webs are reinforced at the ends and are bored with holes 89 ft. 2 in. apart near the top flange. At one end the foot of the web in the vertical end panel of the truss projects below the top flange, between the girder webs and engages a 6½-in. pin through them which joins the fixed bearing. At the opposite end, near the axis of the building the girder webs are bored for a 4-in. pin engaging the tension rod. The girder webs are reinforced by single vertical



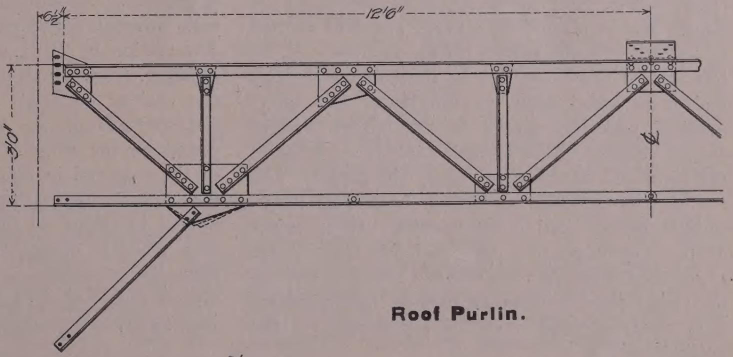
Part Plan and Section of Monitor.



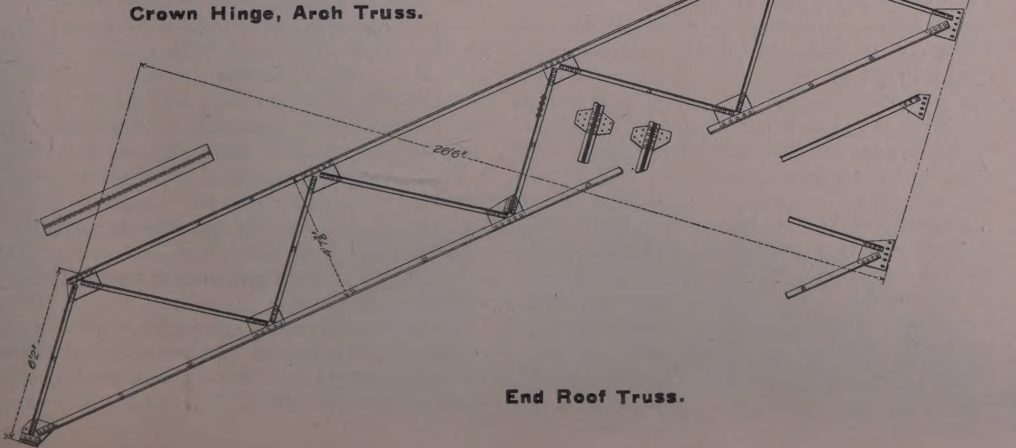
Floor Truss.



Crown Hinge, Arch Truss.



Roof Purlin.



End Roof Truss.

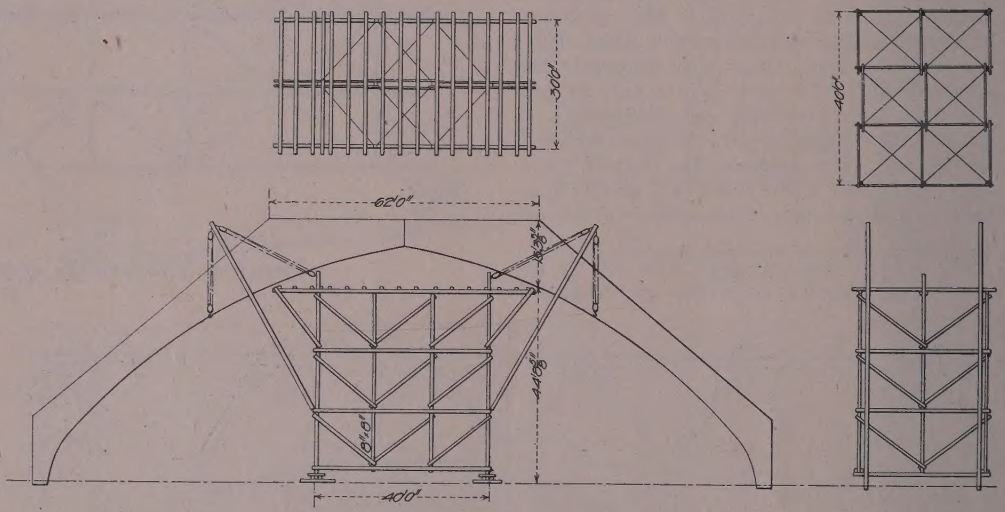
angles about 3 ft. 9 in. apart on the inner and outer faces of the web alternately. The stiffeners are much closer together at the end where eight are spaced over the bearings. A ⅜-in. sole plate 4 ft. long is countersunk riveted to the bottom flanges at each end of the girder and has four slotted holes engaging anchor bolts through a a 24x48-in. cast iron bed plate 3 in. thick.

The pedestals at the expansion ends of the trusses have two vertical longitudinal webs with half-hole pin bearings and full holes in the outside plate. The webs are connected by transverse diaphragms and the pedestals differ from those ordinarily provided for bridge trusses in that the base-plates are about 5 in. wider than the length of the rollers and are provided at both ends with a guide strip engaging the ends of the rollers which are plain cylinders without the center groove and center guide strip usually provided. The masonry bed plates correspond to the pedestal base plate except that they are 6 in. wider and have a 1⅜-in. hole through each end, clear of the guide strip, to engage the anchor bolts.

The purlins are all lattice girders about 3 ft. deep and 26 ft. long, and are bolted at the ends of the top and bottom flanges to the vertical members of the roof trusses. The ends are knee-braced to the trusses and they differ chiefly in the length and inclination of these braces and in the connection plates shop riveted to the top flanges for the lateral and diagonal braces. The inclined purlins in the end panels are simple riveted trusses 74 in. deep vertically with their upper ends attached by bolts through slotted holes in the main roof trusses and their lower ends bearing through horizontal flanges on seats recessed into the brickwork at the end walls of the head houses.

The longitudinal trusses for the drill hall floor are simple lattice girders with horizontal top flanges and curved bottom flanges. The former are made with pairs of 4x3x⅜-in. angles and the latter with pairs of 5x3x⅜-in. angles, both of them riveted together back to back with vertical connection plates between to receive the diagonal members, made with single and double angles riveted together back to back. In the intermediate panels both ends of the trusses are field riveted to the webs of the main girders, as shown at the left end of the drawing. In the end panels, one end is provided with the top flange and intermediate pedestals seated on the girder flanges and the bottom chord is field riveted, as shown at the right end of the elevation of the girder. The roofing tin is nailed to 1¾-in. horizontal longitudinal boards laid close together, 2¾-in. clear at the top flanges of the roof trusses. These boards are supported on spiking pieces bolted to the roof trusses and on 5¾x9¾-in. rafters, about 6 ft. apart notched over the top flanges of the purlins.

The members of the roof trusses were delivered separately and assembled in horizontal planes on the drill hall floor. The completed semi-trusses were erected by two 50-ft. booms in the middle of the end bents of the wooden traveler. This was a 40x60-ft. wooden tower about 45 ft. high, built with twelve 8x8-in. vertical posts braced together with single diagonal planks in all of the vertical panels and with horizontal X-brace rods in the top and intermediate planes. The feet of the vertical posts were seated on longitudinal sills moving on loose wooden rollers placed on pairs of longitudinal timbers. The working platform overhung each end of the traveler 11 ft., and was supported there by knee-braces. From it the upper portions of the semi-trusses were temporarily supported on blocking while the crown hinge connection was made. The dimensions of the traveler were such that two complete arch trusses were assembled while it remained fixed in one position and the purlins, monitor frames and braces were added, completing one panel of the superstructure before the traveler was moved. The erection commenced at one end of the building and the traveler moved continuously through to the other end, completing all erection as it progressed so that it did not return twice over the same places, although it was made with sufficient clearance from the bottom flanges of the roof trusses to enable it to pass under them if necessary. Wm. R. Walker & Son, Providence, R. I., was the architect of the building, and Mr. M. J. Houlihan was the general contractor. The structural steel was designed and detailed, fabricated and erected by the Boston Bridge Works, Mr. M. F. Brown, chief engineer.



Traveler for Erecting Arch Trusses.

The Effect on Cement Mortar of ensilage, manure, lime and sulphur and creosote sheep dips, and other materials has been tested at the Iowa State College. Briquettes of one part of Iola Portland cement to three parts of standard sand were made and tested according to the standard specifications of the American Society of Civil Engineers. According to the account of these tests presented before the Iowa Cement Users' Association by Prof. A. Marston and Mr. M. I. Evinger, from which these notes have been taken, the various materials had little or no effect on the strength of the briquettes. The briquettes tested for the effect of ensilage were kept packed in the material in one of the college silos. For the manure and cinders tests the briquettes were buried in heaps of the materials. The manure was from a horse stable. For the sheep dip tests the briquettes were kept immersed in two dip solutions, one a solution of lime and sulphur, and the other a creosote dip.

Tidal Locks are briefly discussed in a valuable report by the commission appointed to investigate the desirability of a free waterway connecting Chesapeake and Delaware Bays. This waterway will have a maximum tidal range of 10 ft. at its Delaware terminus and 3.8 ft. at the Chesapeake Bay terminus. Assuming the worst possible conditions, it is estimated that the difference in level between the ends of the canal during each tide will ordinarily be 6 ft. and occasionally 10 ft. While the commission was unable in the time at its disposal to investigate the subject carefully, it reached the conclusion that no tidal lock was necessary on a ship canal exposed to such a difference of level at the two terminals. This decision is based on experience on the Suez Canal, the sea-level canals of Corinth and Tasmania, on investigations made by the Board of Engineers which reported recently on an inland waterway from Beaufort to Norfolk, and investigations of French engineers on a tide-level Panama Canal.

A Steel-Lined Irrigation Canal.

A semi-circular canal about 19½ ft. wide and 5,175 ft. long has recently been built across the desert between Assuan and Edfu in Upper Egypt to connect a storage reservoir with the distributing ditches. It has a capacity of 424 second-feet at a velocity of 3 ft. and is enclosed by and supported on an embankment about 10 ft. high, which was made after the steel work was assembled and riveted in position. It is divided into 17 nearly equal lengths, each with expansion joints, in short intermediate masonry sections at both ends. It has seven longitudinal courses of plates nearly ¼ in. thick with lapped joints staggered transversely. The plates are stiffened with external semi-circular 5x3x⅜-in. steel angles 30 in. apart. There is also a 3x2½-in. horizontal angle on each upper edge, to which there is attached an X-bracing of flat bars. Full details of the design were recently printed in "The Engineer" of London.

The ends of the sections have a countersunk-riveted outside plate about 40 in. wide which provides sliding bearings on short sections of horizontal rails built into the masonry. Beyond the ends of these rails the outer faces of the masonry are recessed to form an annular groove around the pipe, filled with a tarred or tallowed rope gasket confined between two angle-iron collars connected by short horizontal bolts passing through the gasket. The collars are set with their flanges at an angle of 45° with the vertical, and the face of the recess is slightly tapered to prevent the gasket from being blown out by the unbalanced pressure. The masonry chambers are about 13 ft. long, leaving a space 6½ ft. long between the ends of the pipes.

A trench about 8 ft. wide and 6 ft. deep was dug in the line of the canal and filled with sand, providing a foundation on which timber cradles were laid about 30 ft. apart. These received the semi-circular stiffening angles to which the plates were assembled, commencing at the center in the bottom and working both ways to the upper ends of the angles. There were about 650,000 ½-in. field rivets, most of them driven by hand by natives, who were not strong enough to operate the six long-stroke pneumatic riveters sent out with the air compressor plant, although they successfully used the pneumatic drills and calkers. Although about 15 per cent. of the machine rivets had to be cut out, the pneumatic machinery worked well, except on account of break-downs in a sand storm and through jamming due to the excessive mid-day heat.

During assembling the plates were kept in approximate positions by two rows of inclined shores on each side. When about 328 ft. was completed it was carefully leveled to a slope of about 1 in 10,000 by jacks set under the cradles, which held it until wet earth had been well rammed under the steel. Transverse excavations under the canal were necessary for riveting the cross seams and through these the wind blew so strongly that it scoured out the loose sand and often caused an entire 328-ft. section to sink several inches during the night. The fierce sunshine also caused unequal expansion on the opposite sides of the canal, sometimes displacing the ends of the sections as much as 4 in., a difficulty for which no remedy was found until after the canal was banked up and filled with water.

The total weight of steel was about 1,250 tons and the work was accomplished by a force of eight Englishmen and 700 other workmen, mostly natives, in five months, working continuously day and night, although the temperature was as high as 117° in the shade. Difficulty was encountered in training rivet heaters, and the rivet holders-on objected to night work on account of the scorpions in the sand. The riveters became sufficiently expert to drive 300 rivets in ten hours, but were unintelligent, had very bad eyesight, and were fond of using the machine oil as a beverage and for annointing their persons. The steel was covered with two coats of an asphalt paint applied from the inside during the night, on account of the extreme heat in the day. Work was suspended from 12 to 3 P.M. during the summer, on account of the heat. Thomas Piggott & Co., Ltd., of Birmingham, England, were the contractors for the French irrigation company.

Book Notes.

Messrs. John Wiley & Sons, New York, have brought out new editions of two books which have long enjoyed such a wide and deserved popularity that any detailed review of them is unnecessary. The first is "Part IV, Higher Structures" of Messrs. Merriman & Jacoby's "Text-book of Roofs and Bridges" ($2.50). This volume is devoted mainly to the theory of stresses and their determination by analytic and graphic methods in the case of structures carried by more than two supports or on two supports where the reactions are not vertical. In the new edition, which is about 50 per cent. larger than the last, there is a much greater number of typical bridges illustrated than before, and the lists of American bridges of each type discussed have been materially enlarged. For the benefit of those not acquainted with earlier editions, it may be said that the continuous girder is treated in less detail than usual, while partially continuous swing bridges receive more than the customary attention, as is the case with cantilever and suspension structures. The treatment of arches is particularly complete, both graphical and analytical methods being used. The second book is H. C. Reagan's "Locomotives" ($3.50). This is a volume for locomotive runners and men interested in the management and handling of locomotives rather than their design. It covers simple and compound steam types and electric locomotives, and its wide sale among a class of discriminating readers is a good indication of its usefulness. The illustrations of the details of locomotives make the book useful, moreover, in reference libraries which aim to be fairly complete in mechanical subjects.

An atlas of useful plates, with full explanatory text, has been prepared under the title of "Graphical Handbook for Reinforced Concrete Design," by Mr. John Hawkesworth. These diagrams give the dimensions of slabs, beams and columns under various conditions of loading, and conforming with the unit stresses prescribed by the Building Code of New York City. The book is intended chiefly for architects and engineers whose work in reinforced concrete design is intermittent in its nature and does not warrant the steady employment of a concrete specialist. The methods of computation used in preparing the diagrams are those outlined in the well-known treatise by Mr. C. F. Marsh and are based on certain maximum allowable superimposed loads and the actual bending moments induced by them. "The true position of the neutral axis under these conditions of actual loading is obtained, and the resisting moment computed in such a way that the working stresses in the steel and in the concrete cannot be exceeded." While the book is not intended to be a treatise on reinforced concrete, the author has wisely given in an appendix the deduction of the various formulas which are the basis of the plates, of which there are fifteen. No. 1 is for use in determining bending moments, Nos. 2 and 3 are for slabs under various conditions of span and loading, No. 4 gives the spacing of square bars required to obtain a given area of metallic cross-section per foot width, No. 5 gives the external bending moment in footings caused by column loads, Nos. 6 and 7 give the resisting moment per inch of width of beams and slabs of various depths, No. 8 enables the areas of metal cross-sections expressed in square inches per foot width to be converted into the total areas for any given width, No. 9 gives the location of the neutral axis, No. 10 gives the shearing resistance of various combinations of concrete and steel, No. 11 gives the dimensions of square columns designed in accordance with the New York Code, No. 12 shows the equivalent stress which can be sustained by various combinations of square columns and longitudinal steel reinforcement when various values are assigned to the unit compressive stress which the concrete alone is permitted to sustain, No. 13 is for hooped columns with six longitudinal rods, No. 14 is for hooped columns with eight longitudinal rods, and No. 15 gives the general design of a reinforced concrete building. Each plate is fully described and there are numerous explanatory examples, so that the use of the diagrams is readily learned. The plates are clearly engraved and printed. (New York, D. Van Nostrand Co., $2.50.)

Letters to the Editor.

The English Channel Train Ferry.

Sir: From the exclusively engineering point of view it is a matter for regret that the British Government has recently decided against the construction of what would have been one of the greatest engineering works of modern times, viz.: the tunnel under the Straits of Dover. This decision of the Cabinet, which was followed by the withdrawal of the bill on the 25th of March, was based on the supposed possibility of foreign invasion by means of the tunnel, and it is not proposed here to discuss this question, which is essentially a military one, but the view which the government took was certainly peculiar. The Prime Minister said in Parliament that, quite apart from the Cabinet's judgment on the value of the military objections which had been made, they considered that no government would be able to persuade the British public that there was no risk of invasion. In fact, the decision which they had come to, unfavorable to the project, was grounded on a fear of a fear, owing to the existence of which the cost of armaments, otherwise unnecessary, would have to be incurred.

Failing the tunnel, which under these circumstances must be put aside, at all events for the present, the project for a channel ferry, which has been talked of for forty years, will now no doubt be pushed forward. Such means of crossing seas, lakes and rivers are, of course, well known in America, in Denmark and elsewhere, and even in Great Britain they were in use before the great bridges across the Tay and the Forth supplanted them; but owing to the importance of the traffic between England and the Continent—not only that between Dover and Calais, the site of the proposed ferry, but between other channel ports which will be attracted to the ferry—this scheme will have a special interest which attaches to no other.

In order to construct the necessary pier and appliances at Dover, Parliamentary sanction was obtained last year.

The plans at the English side involve the construction of a pier designed by Sir Douglas Fox & Partners, within the existing harbor, 1,377 ft. long, and 100 ft. wide to 450 ft. from the shore, where it is recessed on the western side to 47 ft., leaving 53 ft. for the lift 300 ft. long, and the ferry boat, which will be berthed end on to the lift. The latter, which will have a vertical range of about 24 ft., will take on its two tracks, these being in alignment with those on the pier and on the ferry boat, a train of the aggregate length of 700 ft. and weighing over 400 tons. This structure, which will be worked electrically, has been designed by the Compagnie de Fives-Lille, and the cost of movement up and down for the mean range of tide has been estimated at about $4. The connection between the lift and boat will be by a hinged apron bridge of about 30 ft. span, so as to provide for the fall and rise of the boat under the influence of the reception of, and relief from, the weight of the train in loading and unloading.

The arrangements for the pier and lift at Calais will be somewhat similar to those at Dover.

The passenger ferry boats are 400 ft. long and are designed by Sir William White, K.C.B., F.R.S., late chief constructor of the British Navy, and the firm of Sir W. Armstrong, Whitworth & Co., of Elswick, the latter firm having been connected with similar ferry proposals across the channel since 1872, and having constructed the ferry steamer "Baikal," which has done such good service across Lake Baikal in Siberia, pending the construction of the Trans-Siberian Ry. round its southern shore. When the train has been embarked the passengers will find themselves in what is to all intents and purposes a well-arranged station; there will be wide platforms, waiting, smoking, refreshment and private rooms for the use of those who wish to leave the train. This accommodation will be for the most part above the standing trains, which will be thus under shelter both on the boats and in the lift. The boats, which will be driven by turbines at a speed of 23 knots, have been designed with the view of great stiffness, and a wide range of stability, and though the sea in the Straits is often what is called "choppy," it is not of a character to affect large craft seriously, as regards either rolling or pitching. A distinct feature in the design is found in the bascule doors at each end of the train shelter. These can be opened or closed quickly by means of powerful mechanism, preventing any spray from reaching the cars, even when the steamer is driven at full speed against a head wind. The coal consumption for the 21-mile passage is estimated at 10 tons per trip. It is proposed to provide passenger boats sufficient for eight trips daily, three by day and one by night, each way. The freight boats will be somewhat smaller than the passenger ones, and have been designed by the Chantiers de St. Nazaire in France, and will carry 38 short 18-ft. freight trucks, or their equivalent.

The passenger cars, to be provided by the International Sleeping Car Co., will be 65 ft. long and 9 ft. 5½ in. wide, and will be of the corridor type. The freight cars, generally, will be of the ordinary description, but as the traffic in perishable goods is expected to be large, owing to the avoidance of transshipment, special aerothermic wagons have been designed for this work. To prove the value of this one of these wagons was loaded up with peaches and grapes at Perpignan, in the south of France, and run to Dieppe, where the wagon with its load was put on board a steamer crossing the Channel, unloaded in the same way at Newhaven on the English side, and run to London, being 63 hours on the road. The temperature within the cars was about 43° Fahr., and outside it from 50° to 70°, averaging about 61°. Owing to this and to absence of the double transshipment the fruit fetched in the London market about 25 to 33 per cent. more than similar consignments sent in the ordinary way.

The American system for the interchange of rolling stock, which has been for a long time in existence for Anglo-Scottish traffic, will be established. Special extra rolling stock will have to be furnished, for not only will the extra mileage of what is virtually, in this sense, a railway line, have to be provided for, but though the gauge is the same on both sides of the Channel, the present Continental rolling stock is in many cases wider and higher than English structures will allow for. Hence the existing stock is only interchangeable within certain limits.

As to the comparative speed of the through traffic by tunnel and ferry, it is to be noted that the plans for the tunnel showed a considerable amount of what may be called ineffective length. Owing to considerations of defence, the English outlet was required to be under the guns of the Dover forts, and as also length had to be provided to give a practicable grade, a spiral had to be introduced doubling back to Dover, adding about five miles to the direct route. On the French side the approach is at right angles to the general direction for about the same distance, so as to have the mouth of the tunnel assailable from the sea. As, in addition to this, severe grades are necessary to rise from the submarine levels required, much of the time expended in dealing with these would have gone against that necessary in the ferry scheme for the transfer between wharf and boat, and for the slower progress of the latter across the straits.

This enterprise affects American travel. Both the British Admiralty and the Harbor Board are spending large sums in greatly improving the harbor accommodation at Dover, and already it is a port of call for six ocean steam companies, viz.: the Hamburg-American, the Red Star, Deutsche Sud-Afrika, Hamburg South American, Deutsche Levant and the Shire Line. Probably other companies may follow these examples when the harbor works are complete, for a glance at the map will show that, for all traffic between German, Dutch and Belgian ports, and the Atlantic, a call at Dover entails the minimum departure, as compared with any other English port, from their shortest course. Should the ferry be established and suitable transatlantic boats touch at Dover, passengers from America to the Continent of Europe direct can complete their journey with only a break at Dover, proceeding thence, without further change, to any part of the Continent.

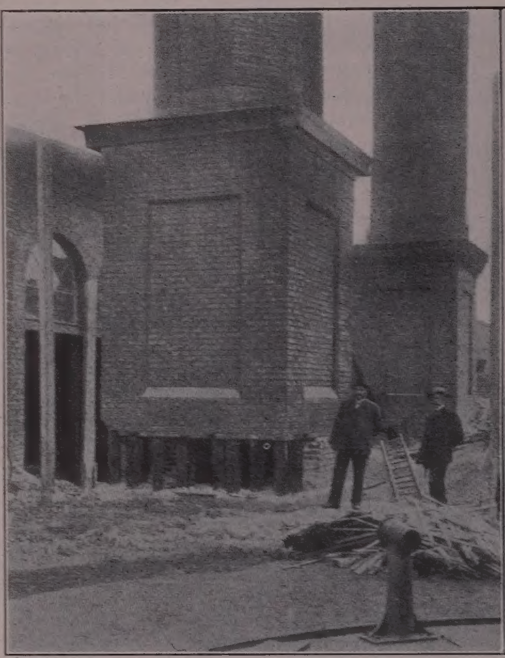
Some of the particulars given above have been derived from a recently published work called "The Channel Ferry," by E. de Rodakowski.

London. C. O. BURGE.

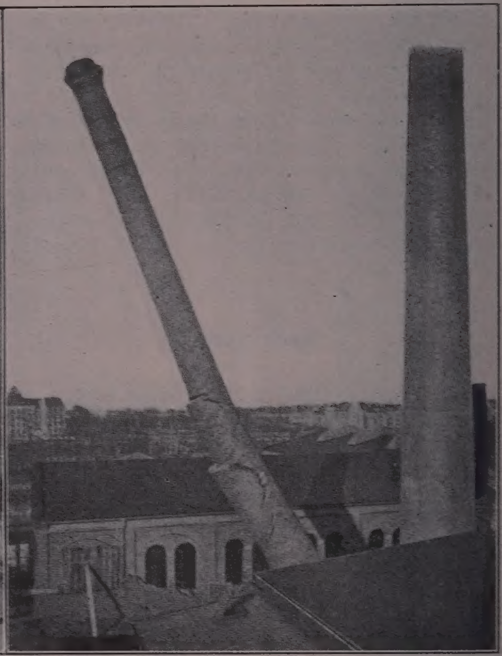
DEMOLITION OF TWO SMOKESTACKS.

SIR: I send you herewith a translation of a German report on the demolition of two large smokestacks in Munich, executed by Joseph Houzer, of that city, at the machine shops of the Central Terminal of the Royal Bavarian State R. R. A stack 50 m. high, located between two older stacks 32 m. high, was constructed by this contractor, and after it was finished the two smaller chimneys became obsolete and were accordingly demolished. In place of the old time-consuming and expensive operation of building scaffolding around the stack and taking the material down by hand, the contractor decided to allow the stacks to fall in a direction previously determined. As the old chimneys flanked the new one and only a small space was available for the falling of the former, the problem was a somewhat difficult one, particularly as the stacks stand between substantial buildings of considerable extent, and it was impracticable to use explosives in the wrecking operations. It was decided that one stack must fall east and the other west.

The work proceeded as follows: The foundation and part of the masonry above ground were carefully removed on that side of each stack facing the direction of fall, and strong timber shores were inserted in the space thus gained, as shown in the accompanying figure. Around these shores firewood was piled and a quantity of wool waste was spread around and within the wood. Petroleum was then sprinkled over the mass and after the two corner shores had been removed the wood was set on fire. Thereupon the stack slowly assumed an angle as a whole, and finally fell exactly in the calculated direction, its appearance while falling being shown in an accompanying picture. When the cloud of soot and dust had settled it was found that the greater part of the brick was uninjured and apparently clean, as the friction of the air had probably removed the soot. From the time the wood pile was set on fire until the chimney fell in a mass of wreckage 4 minutes elapsed.



Stack Held by Posts.



View of Falling Stack.

Yours truly, THEODORE ROSENBERG.

Glenwood Springs, Colo., March 28.

INJURY TO PAVEMENTS BY HIGH-PRESSURE FLUSHING.

SIR: When examining pavements of different kinds in different cities during the past ten years, I have noticed many of them seriously injured and some destroyed by flushing with water forced down upon them or diagonally across them, sometimes direct from hydrants, from attached hose and from flushing wagons from which water issues under compressed air. The injury and destruction are not only done by erosion on the surface of several kinds of pavements, but by means of the water penetrating through joints and small openings and thus getting under the pavement as a whole or under the blocks of streets paved with bricks or stone blocks. An illustration of the powerful effect of water thus penetrating is as follows:

Take an average paving brick 8x3x4 in. deep. It has 24 sq. in. on its under side. If water at 60 lb. per sq. in. penetrates below the brick, a theoretical hydraulic lifting pressure is developed of 24 times 60, which is 1,440 lb. under the brick. Allowing for escaping water and loss of pressure so that only one-fourth of this is effective pressure, we have 360 lb. under the brick weighing only 9 lb., as this is the average weight of paving bricks of block size. The brick is retained in place only by cement mortar or grout around it. There are many pavements without this cement and even if present it is not perfect at all points and many bricks become loosened, especially those which are constantly jarred by traffic and which are near street rails. Thus water applied from hydrants and flushing machines constantly lifts paving bricks from their bed and loosens them, aiding in the steady destruction of the pavement as a whole. This injury is also done to asphalt and other monolithic pavements. The small particles of sand or other component grains of the pavement are tiny paving stones between and under which tiny particles the water under pressure works its way. Engineers and those interested in street paving have but to bear in mind what I have stated above when they are looking at pavements in St. Louis, Chicago and other cities, which pavements are constantly flushed and seriously injured by the hydraulic effect of water thus improperly used in cleaning them. I have often seen asphalt blocks weighing 16 lb. lifted from their bed and the largest granite blocks also steadily displaced until the entire pavement is uneven and as a whole no longer what it should be.

Water should not be used under pressure for cleaning pavements of any kinds, although it is proper to use it for prevention of dust while sweeping or when thoroughly wetting pavements previously to cleaning them with large rubber scrapers, as in Berlin, Paris and other important European cities where the streets are kept clean.

New York, April 5. J. W. HOWARD.

NEW YORK CANAL IMPROVEMENT BONDS are being sold with great difficulty.